What can we see with the first fb^{-1} ?

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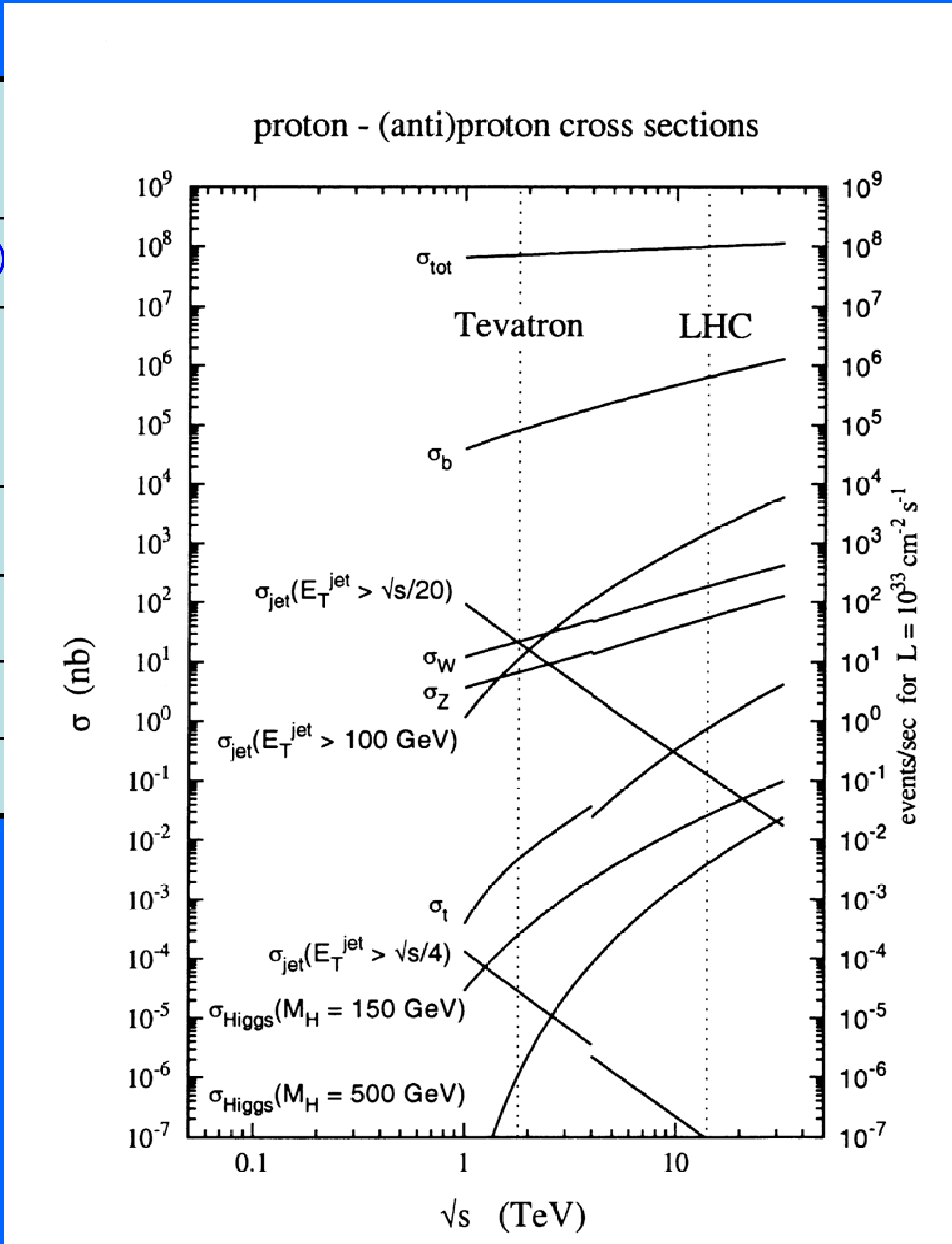
University of Glasgow
IoP Half day meeting on the First Year of the LHC

Outline

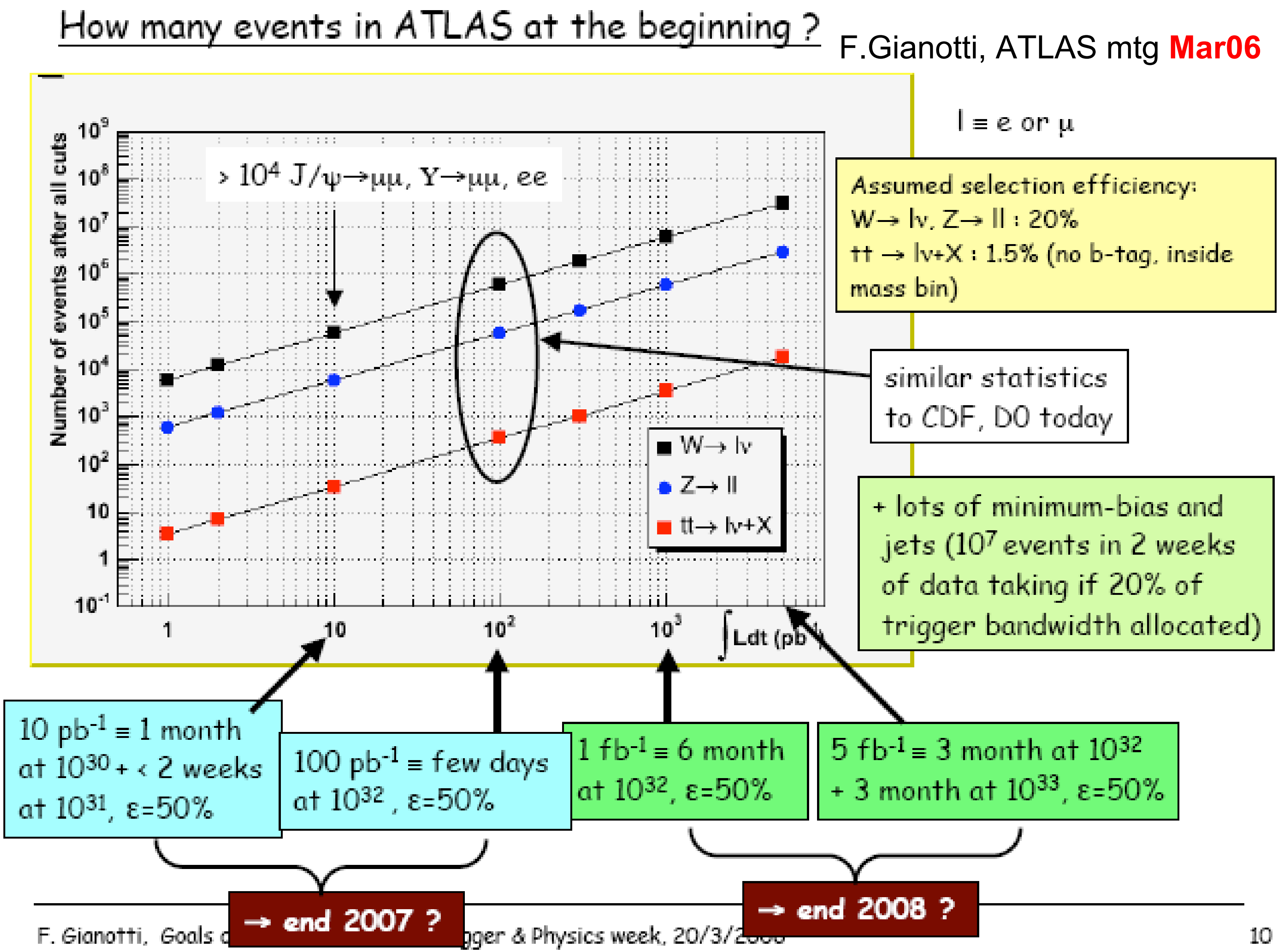
- A look at what physics results we can expect with $1fb^{-1}$ at 14TeV
  - Will not talk about 900GeV
- Topics under study
  - Soft physics: minimum bias and the underlying event
  - Jets: inclusive jets, dijets, azimuthal decorrelation, multijets
  - W, Z production: W and Z rates, PDFs from W-rapidity, W-mass, dibosons
  - Top production
  - Early SUSY: jet+MET
  - Early Higgs: ingredients for a Higgs search
- This is only a selection – apologies if I missed your favourite topic

LHC numbers @ 14 TeV

Process	σ (nb)	Recorded $L = 1\ fb^{-1}$
MB	10^8	$\sim 10^6$ (10% bandwidth)
Inclusive jets **$p_T > 200$ GeV**	100	$\sim 10^6$ (10% bandwidth)
$W \rightarrow e\nu$	15	$\sim 10^7$
$Z \rightarrow e^+ e^-$	1.5	$\sim 10^6$
dibosons	0.2	$\sim 10^2$
gg (M~1TeV)		10^2-10^3



F.Gianotti, ATLAS mtg **Mar06**

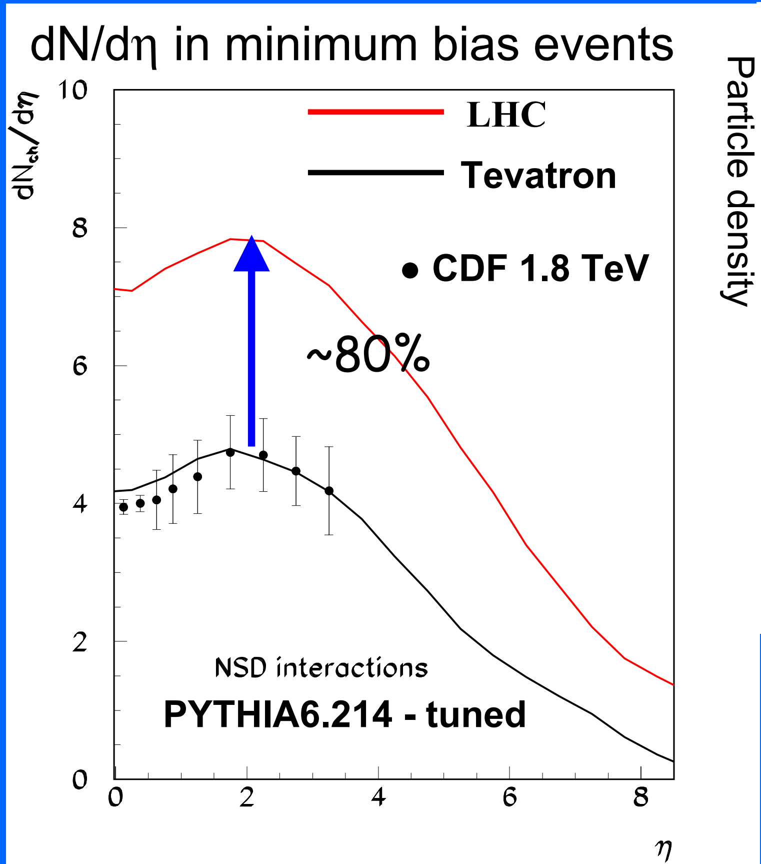


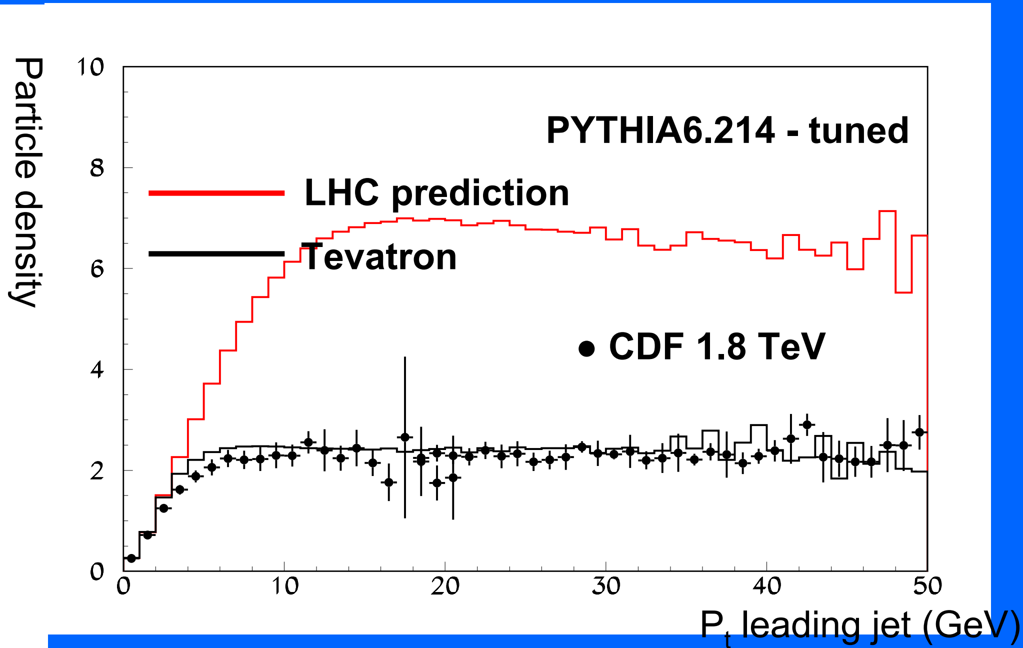
Soft physics

Minimum bias

Underlying event

Minimum bias and Underlying Event: LHC predictions





Minimum bias = inelastic pp interaction
Underlying event = hadronic environment not part of the hard scatter

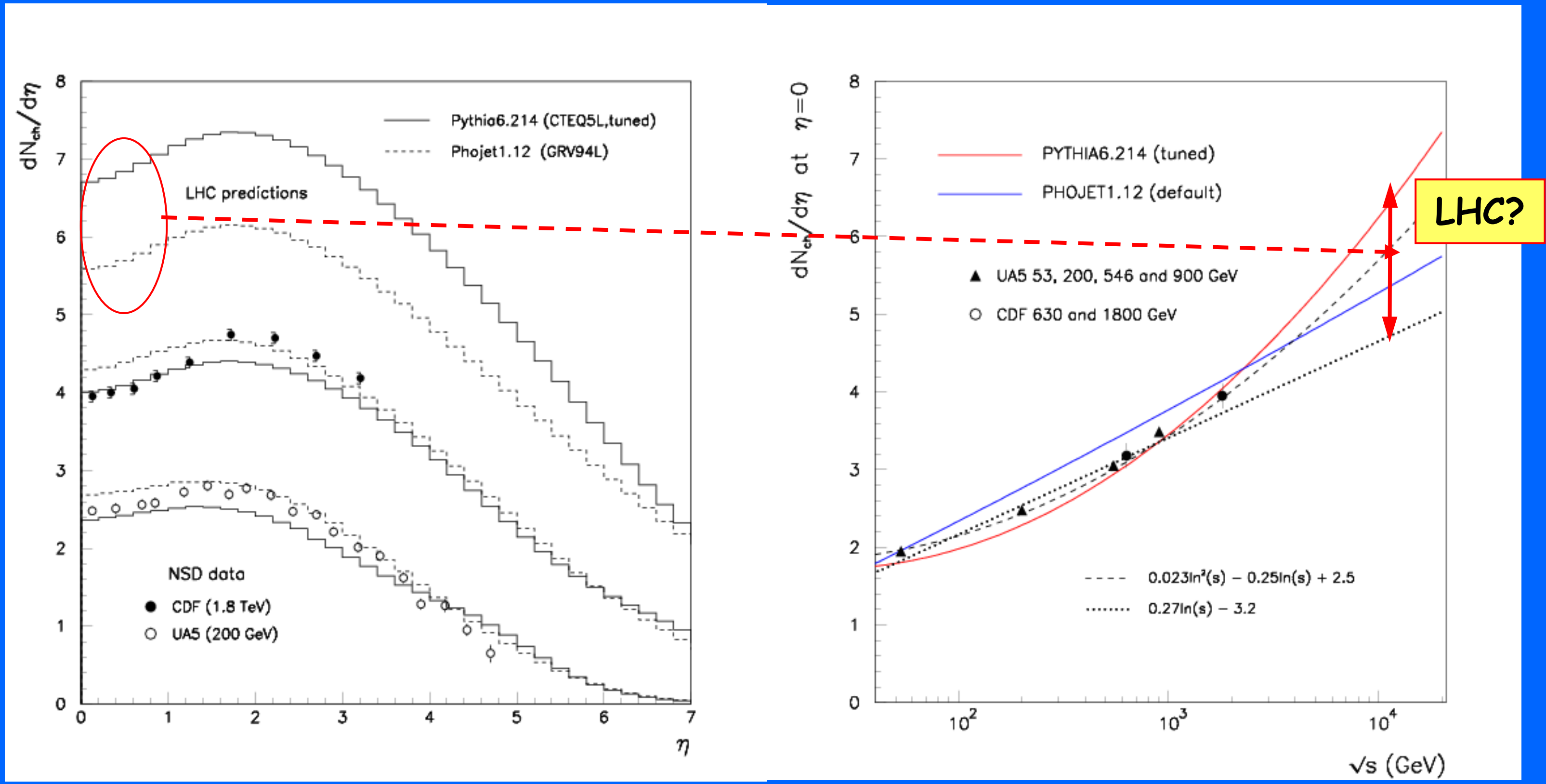
	dN/dη (η=0)	N_{ch} jet-p_t=20GeV
1.8TeV (pp)	4.1	2.3
14TeV (pp)	7.0	7.0
increase	~x1.8	~x3

MB only

UE includes radiation and small impact parameter bias

Minimum bias studies: Charged particle density at $\eta = 0$

Why? soft physics, pile-up at higher luminosities, calibration of experiment

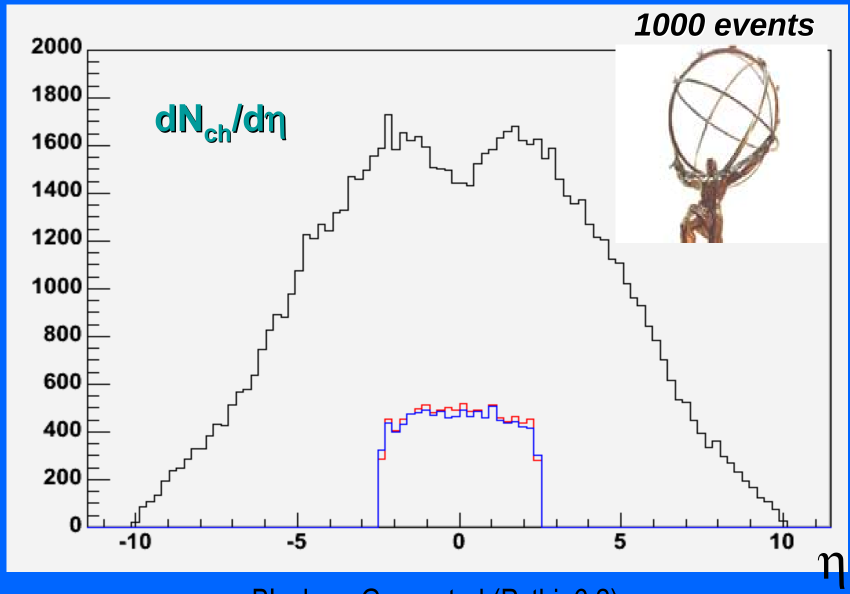


Large uncertainties in predicted particle density in minimum bias events ~x2

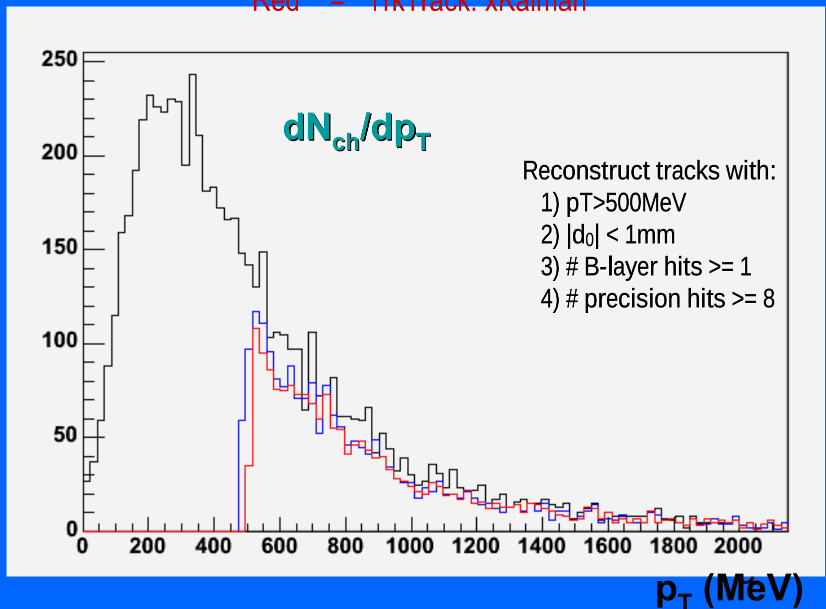
→ Measurement with central tracker at level of ~10% with ~10k events – first data

Tracking in MB events

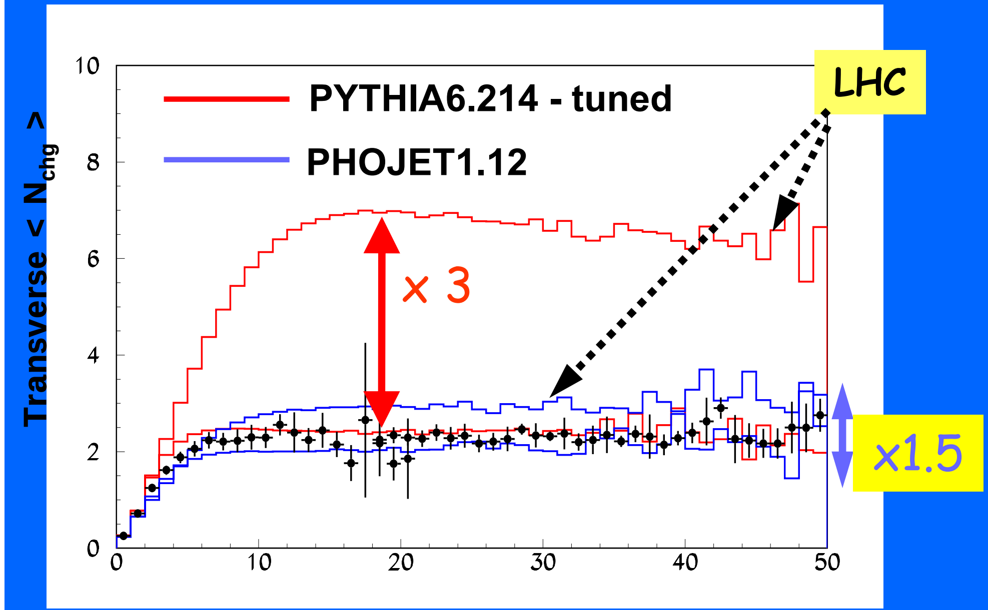
- Acceptance limited in rapidity and pt
- Rapidity coverage
  - Tracking covers |η|<2.5
- p_T problem
  - Need to extrapolate by ~x2
  - → Need to understand low pt charge track reconstruction

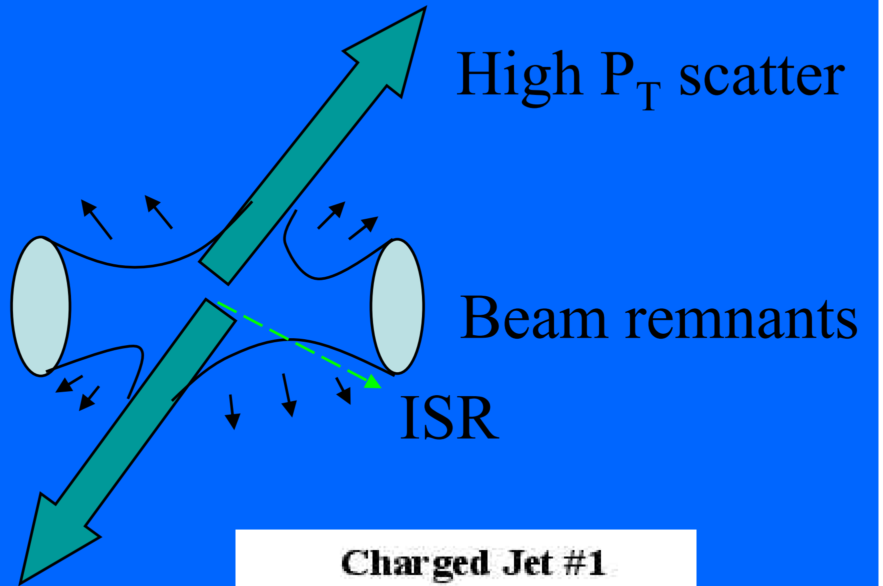


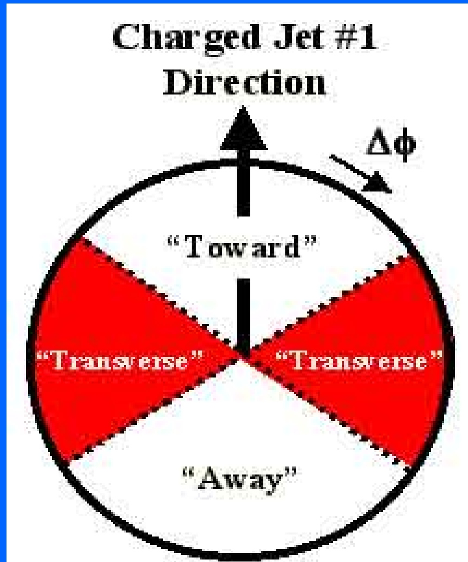
Black = Generated (Pythia6.2)
Blue = TrkTrack: iPatRec
Red = TrkTrack: xKalman



The underlying event







Extrapolation of UE to LHC is unknown
Depends on

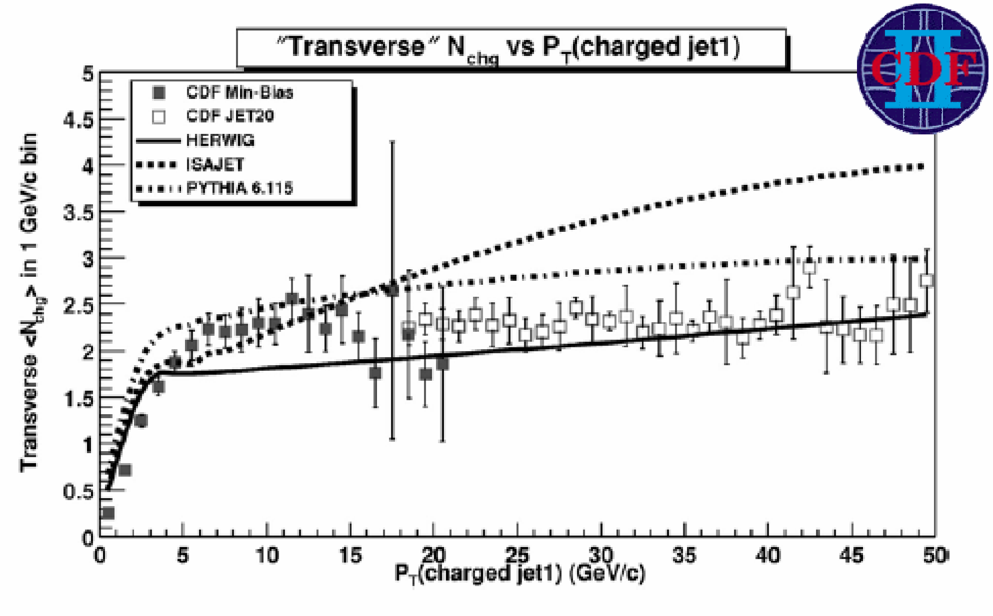
- Multiple interactions
- Radiation
- PDFs
- Striing formation

- Lepton isolation
- Top
- Jet energy
- VBF

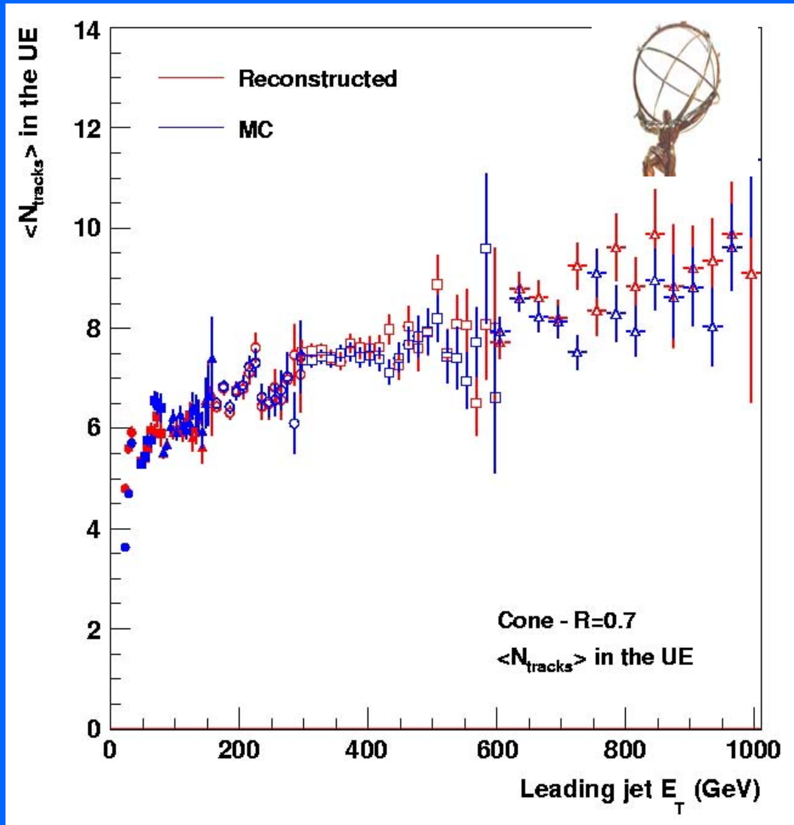
Reconstructing the underlying event

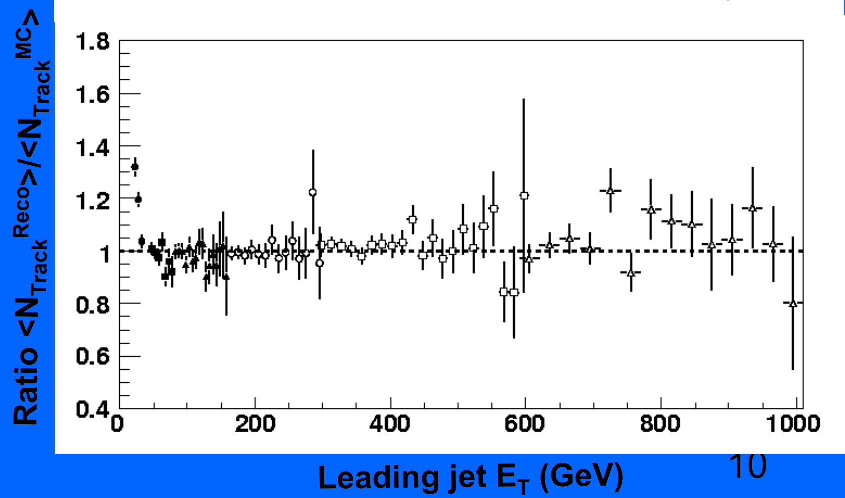
Njets > 1,
|ηjet| < 2.5,
ETjet >10 GeV,

|ηtrack | < 2.5,
pTtrack > 1.0 GeV/c



CDF Run 1 underlying event analysis
Phys. Rev. D, **65** 092002 (2002)





Jets

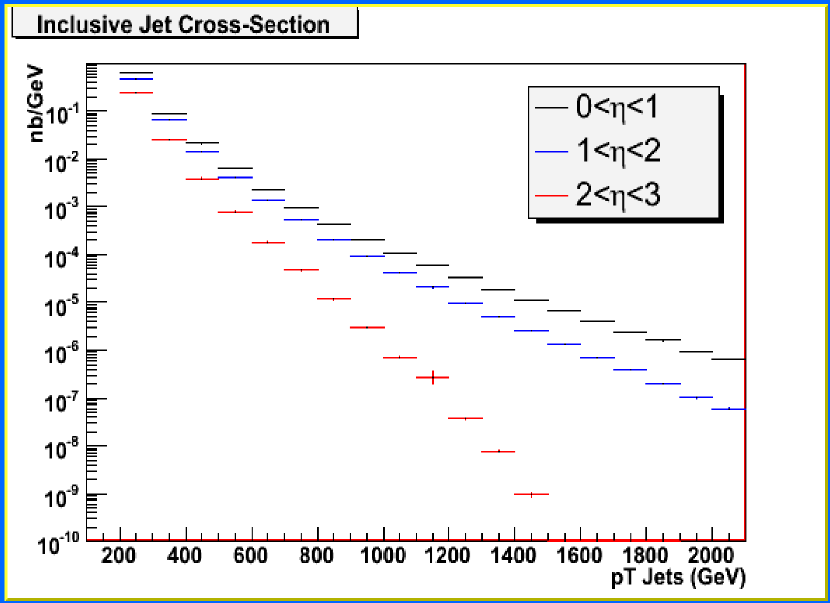
Inclusive jets and PDFs

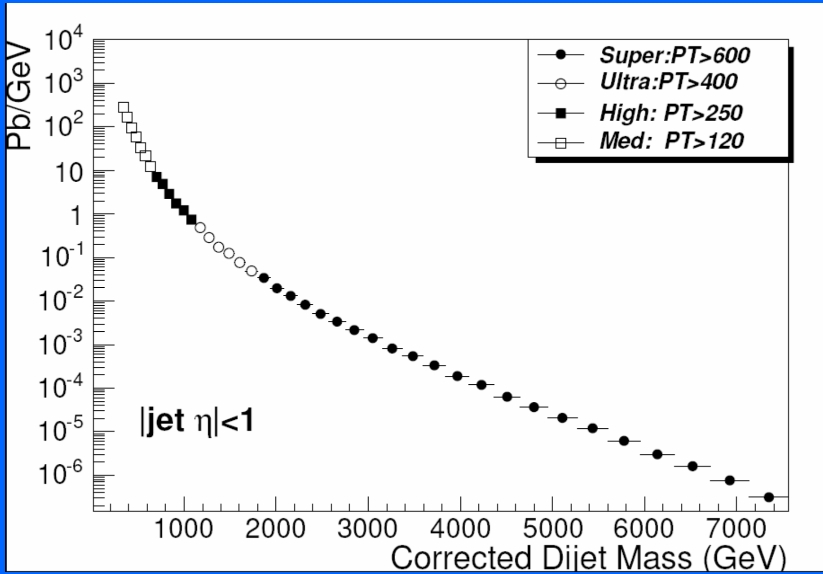
Azimuthal decorrelation

Multijets

The Inclusive Jet Cross-Section

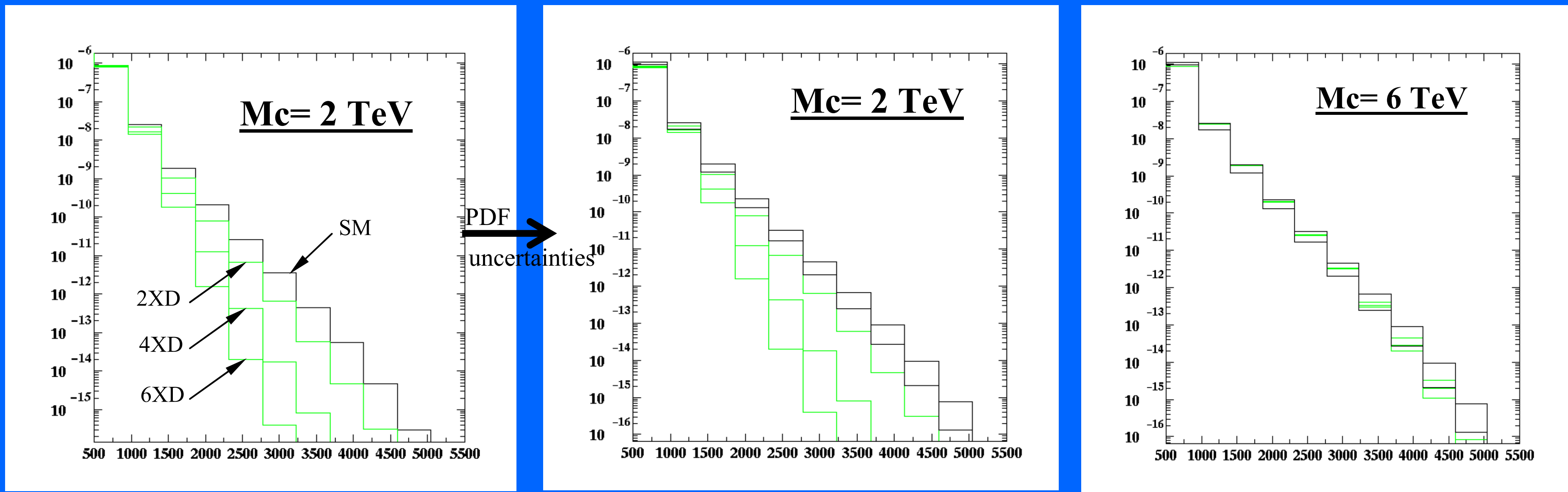
- Test QCD
- Measurement can also be used to look for new physics (e.g. quark compositeness).
- ~100 events with Et>2TeV for 1fb^{-1}





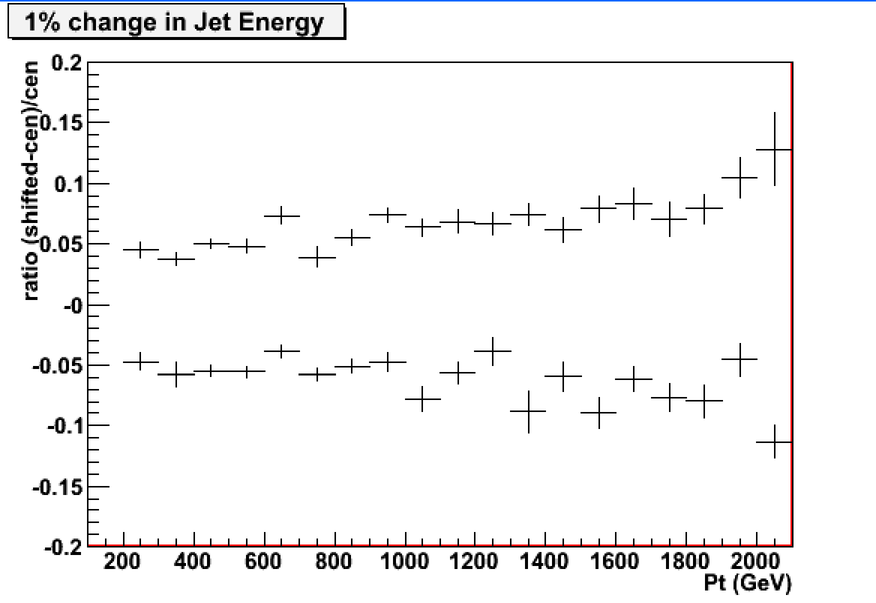
Impact of PDF uncertainty on new physics

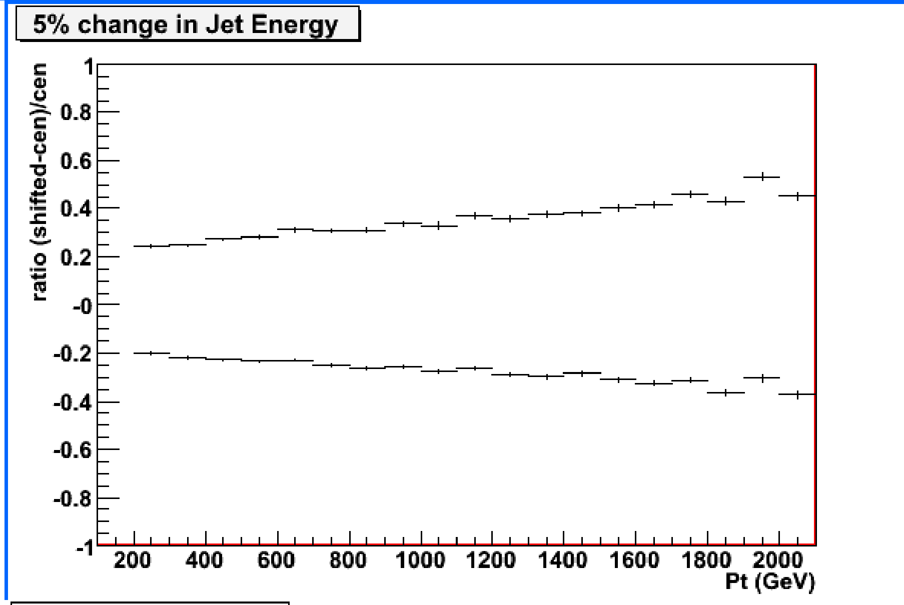
- Extra-dimensions affect the di-jet cross section through the running of α_s. Parameterised by number of extra dimensions D and compactification scale Mc.
- PDF uncertainties (mainly due to high-x gluon) reduce sensitivity to compactification scale from ~5 TeV to 2 TeV



- Similarly PDF uncertainties limits the sensitivity in inclusive xsect to BSM physics

Effect of PDFs and jet energy scale on inclusive jet spectra



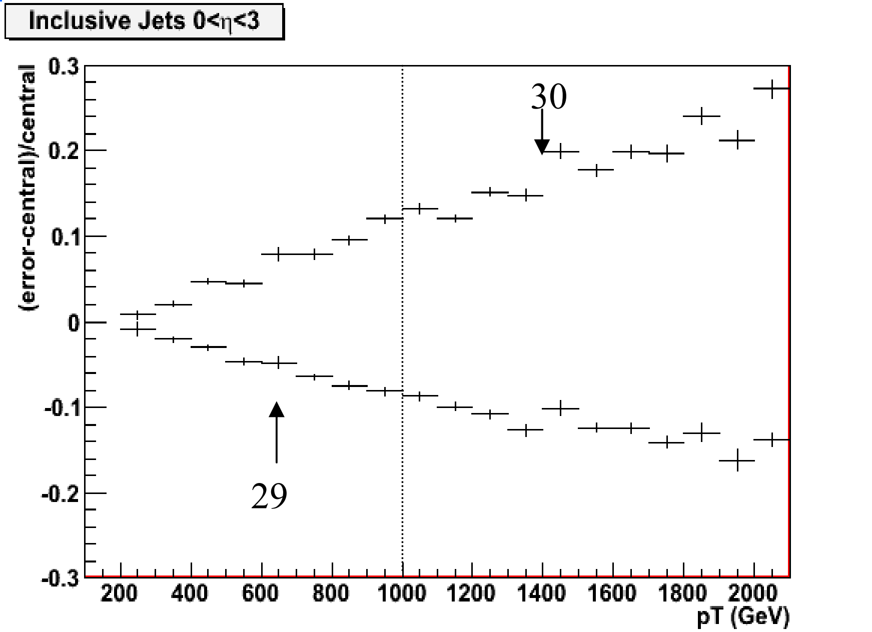


For a jet with pT=1TeV:

1% error on jet energy -> 6% on σ

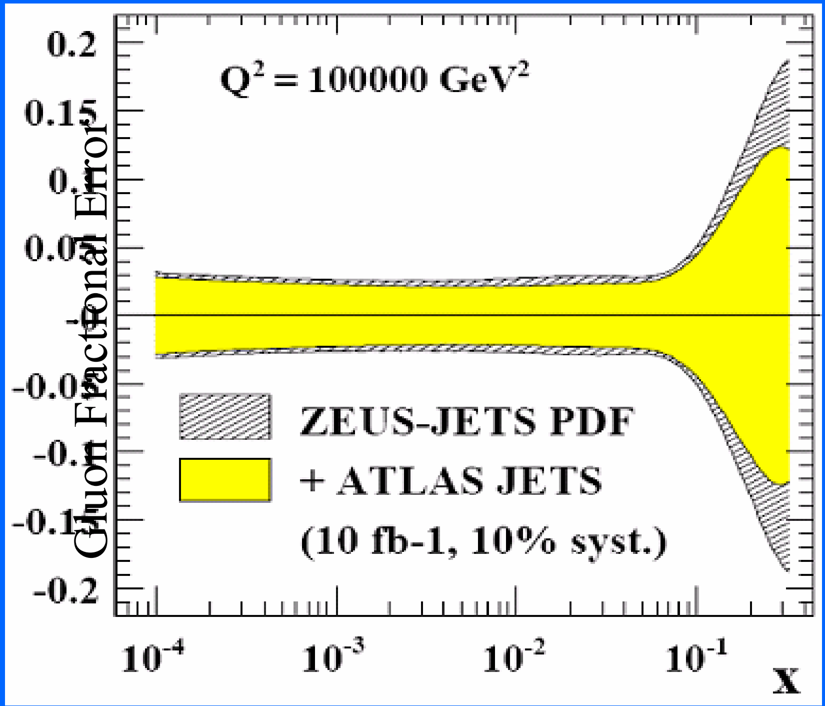
5% error on jet energy -> 30% on σ

10-15% uncertainty due to g-PDF



PDF Fitting Using Pseudodata

- Grids were generated for the inclusive jet cross-section at ATLAS in the pseudorapidity ranges $0<\eta<1$, $1<\eta<2$, and $2<\eta<3$ up to pT=3TeV (NLOJET).
- In addition pseudodata for the same process was generated using JETRAD
- The pseudo-data was then used in a global (ZEUS) fit to assess the impact of ATLAS data on constraining PDFs:

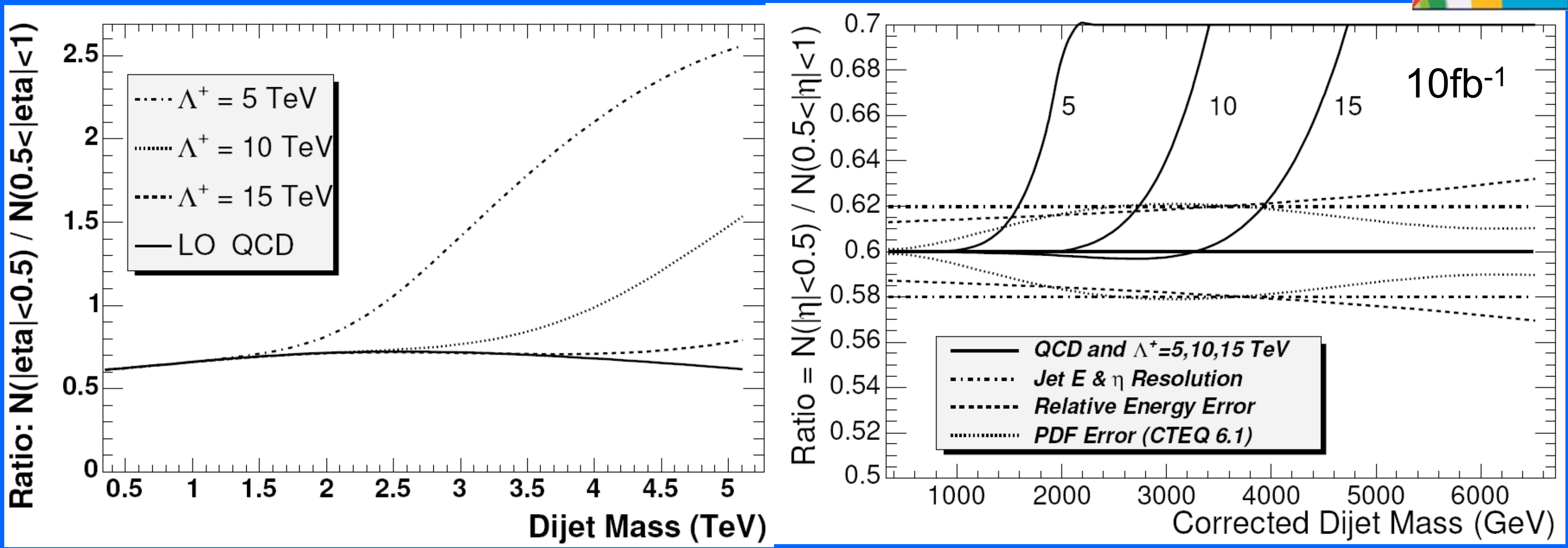


Preliminary indications suggest that ATLAS data can constrain the high x-gluon.

Systematic errors are uncorrelated, $10fb^{-1}$=1 year of nominal data-taking

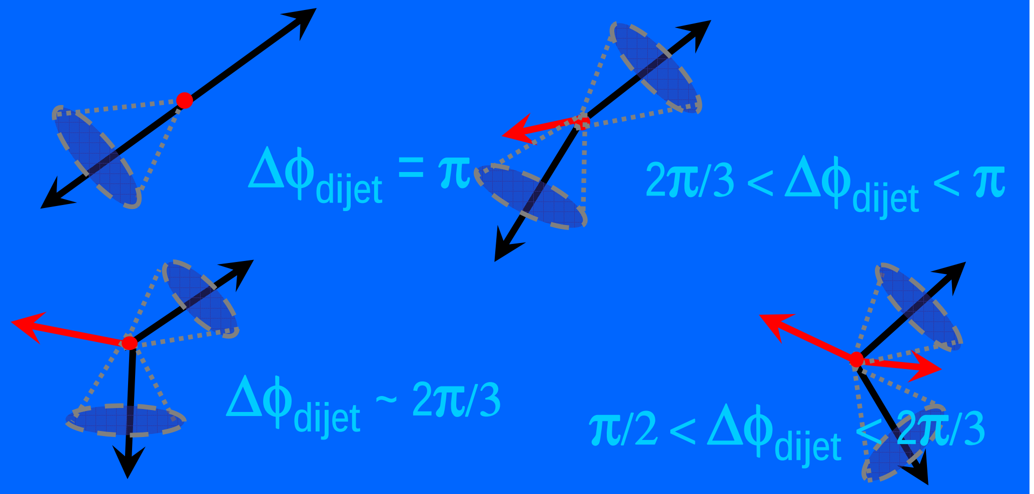
BUT jet energy scale ~ few % required

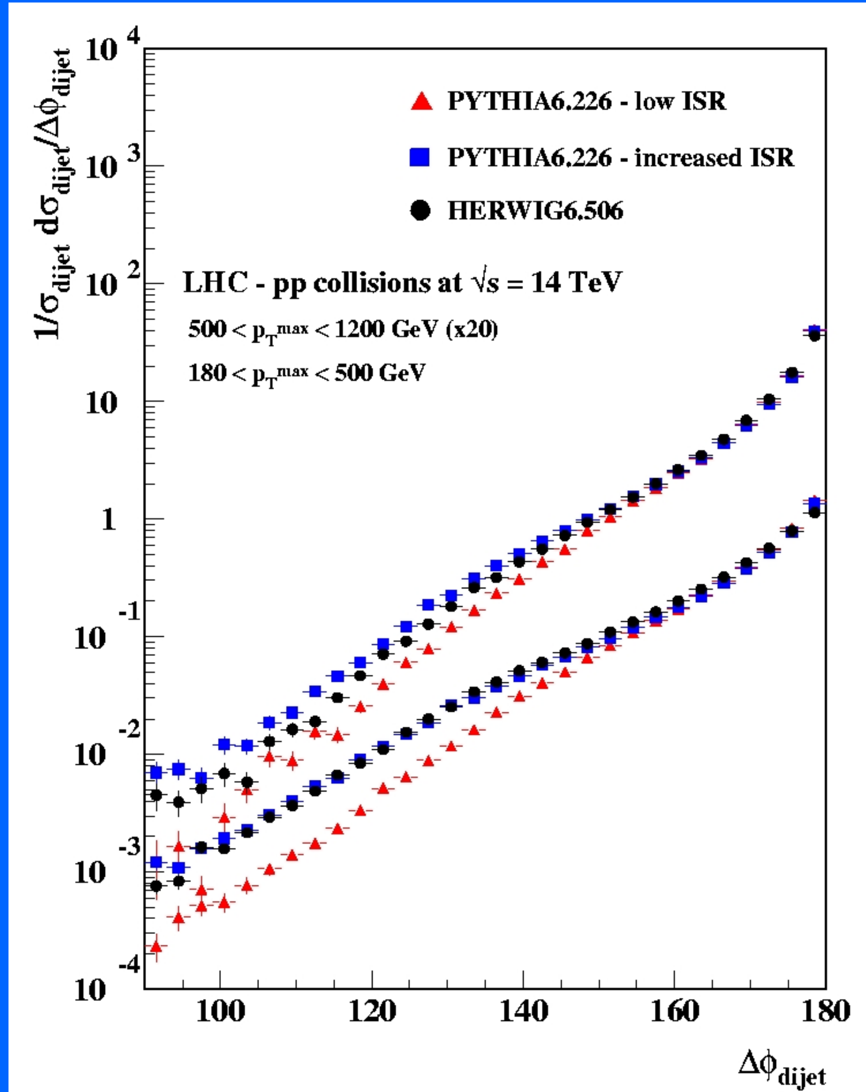
Searches with dijets



- Use ratio of central dijet events to forward dijet events
- Sensitive to compositeness models

Azimuthal dijet decorrelation





Early measurement to benchmark generators particularly parton showers/higher orders

Reconstructed di-jet azimuthal decorrelations

Selecting di-jet events:

Cone jet algorithm (R=0.7)
$N_{jets} = 2$,
$|\eta_{jet}| < 0.5$,
$E_T^{jet\ \#2} > 80$ GeV,

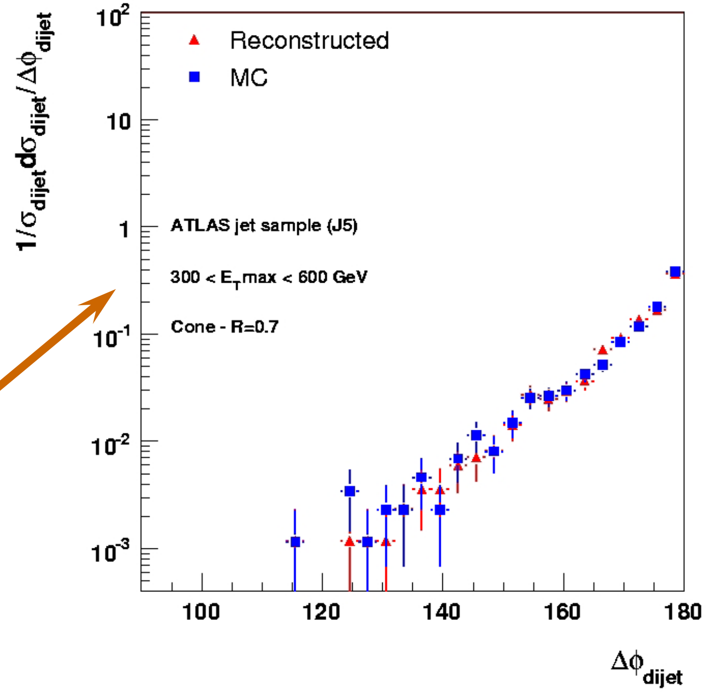
Two analysis regions:

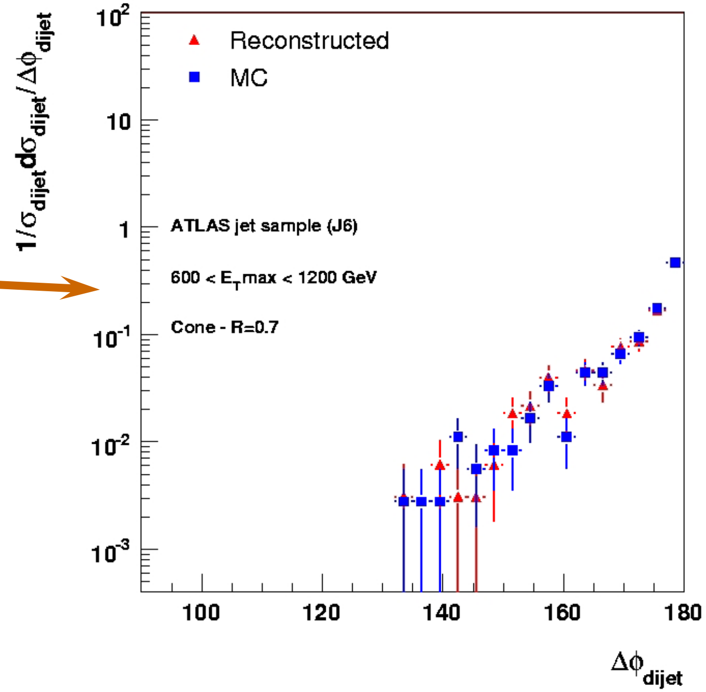
$300 < E_T^{MAX} < 600$ GeV

$600 < E_T^{MAX} < 1200$ GeV

J5

J6

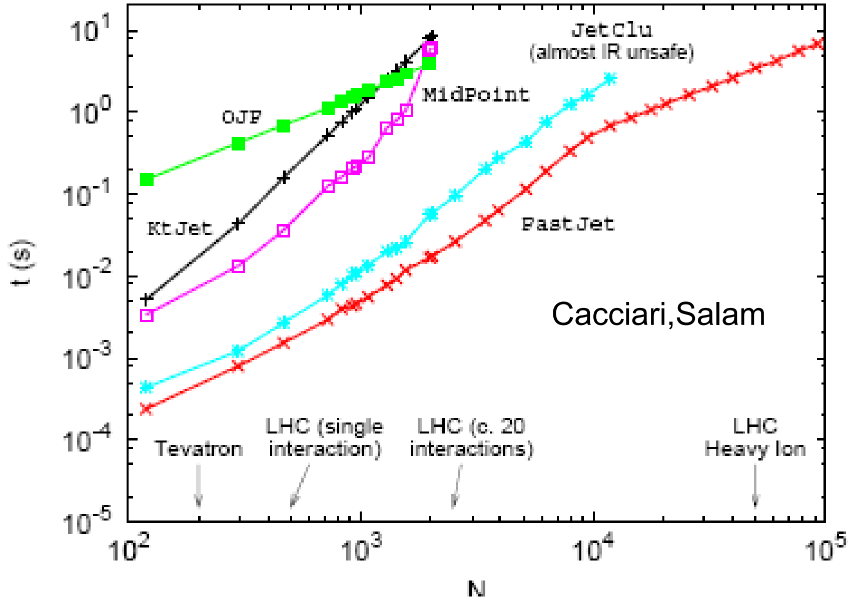


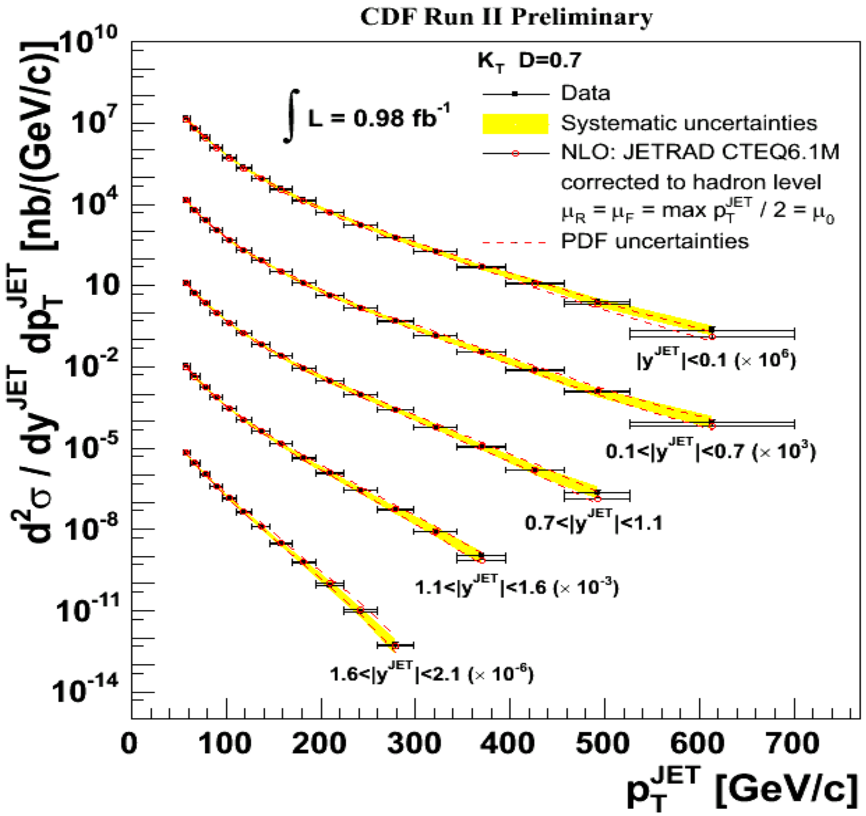


Jet algorithms

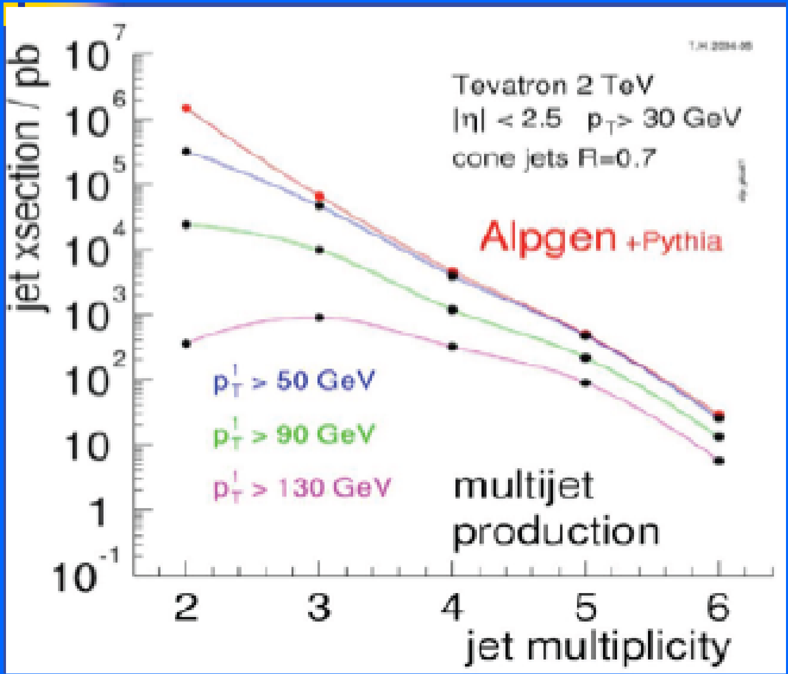
- Traditionally cone algorithms used at hadron colliders, now K_T being used
- Cone algorithms
  - Relatively fast
  - Not IR safe
- Kt algorithm
  - Slow ← solved
  - UE subtraction
  - IR safe
- Algorithms are complementary for estimating systematics e.g. for top mass::
  - Kt sensitive to UE and isr
  - Cone sensitive to FSR and hadronisation

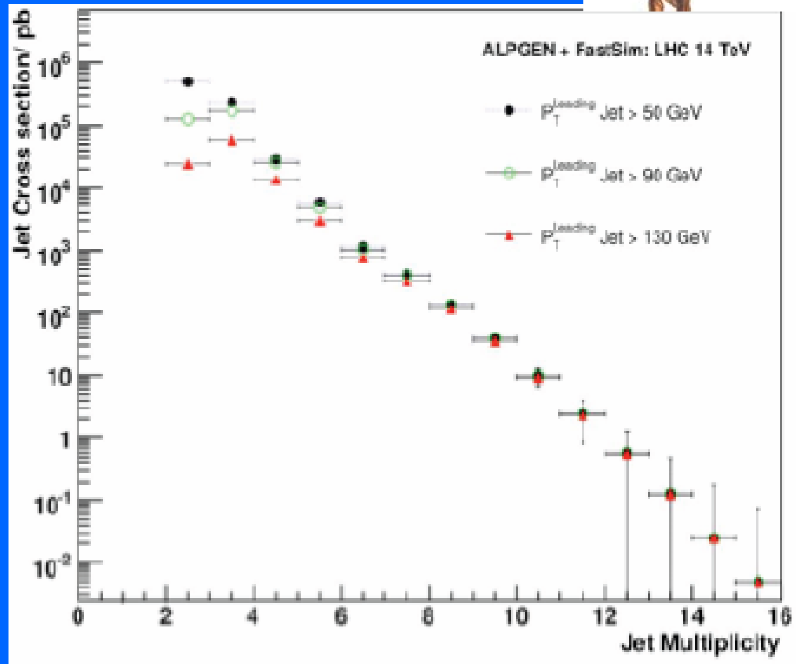
(Seymour+Tevlin hep-ph/0609100)



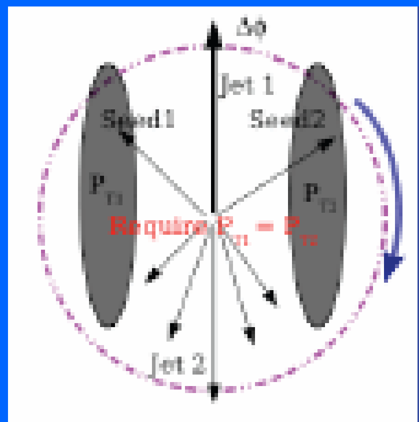


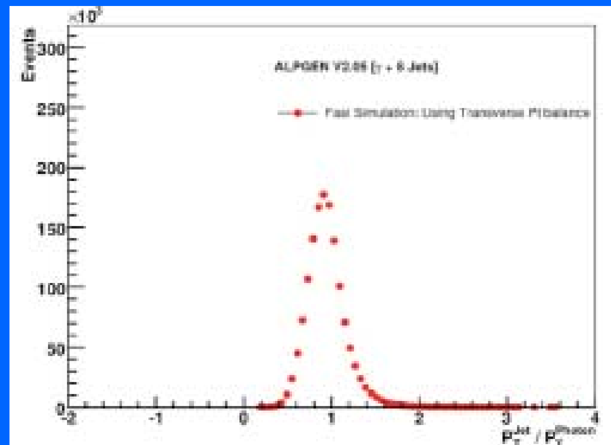
Multijets





At LHC large multijet multiplicities
→ Require care in calibration





W and Z

W, Z rates
PDF measurement in W-production
W-mass
Dibosons

W and Z inclusive production

- Well understood theoretically
  - Dominant uncertainty is due to PDFs
- For $1 fb^{-1}$

$\Delta\sigma/\sigma(pp \rightarrow Z+X \rightarrow \mu\mu+X)=0.13 \pm 2.3 \pm 10\%$

$\Delta\sigma/\sigma(pp \rightarrow W+X \rightarrow \mu\nu+X)=0.04 \pm 3.3 \pm 10\%$

Stat sys lumi

Tracker efficiency
PT (LO→NLO)

Muon efficiency
Trigger efficiency
MET
PT(LO→NLO)

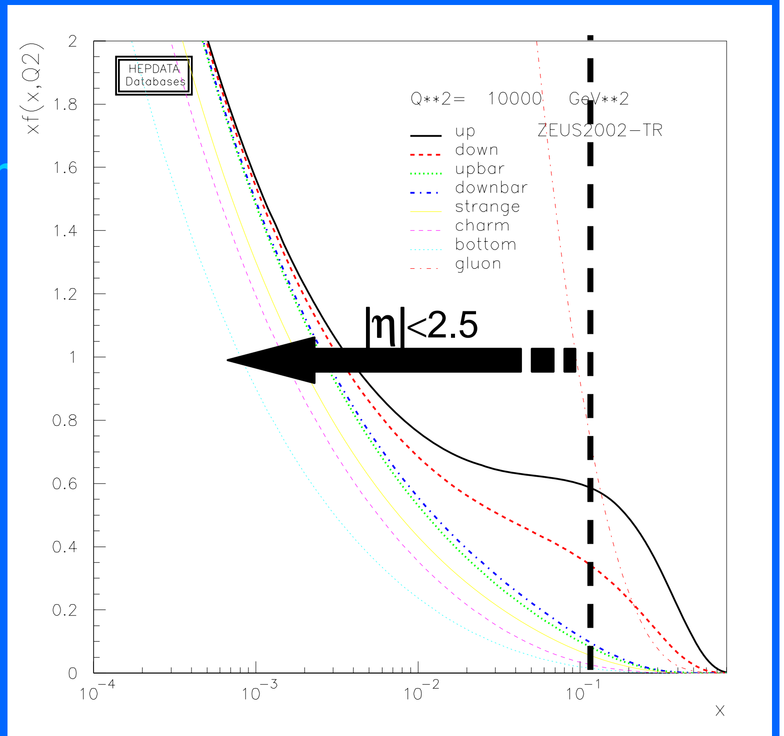
Equivalently can use to evaluate luminosity at the level of 6-7%

Improving the PDFs

The uncertainties on the W and Z rapidity distributions are dominated by the uncertainties along gluon PDF dominated eigenvectors

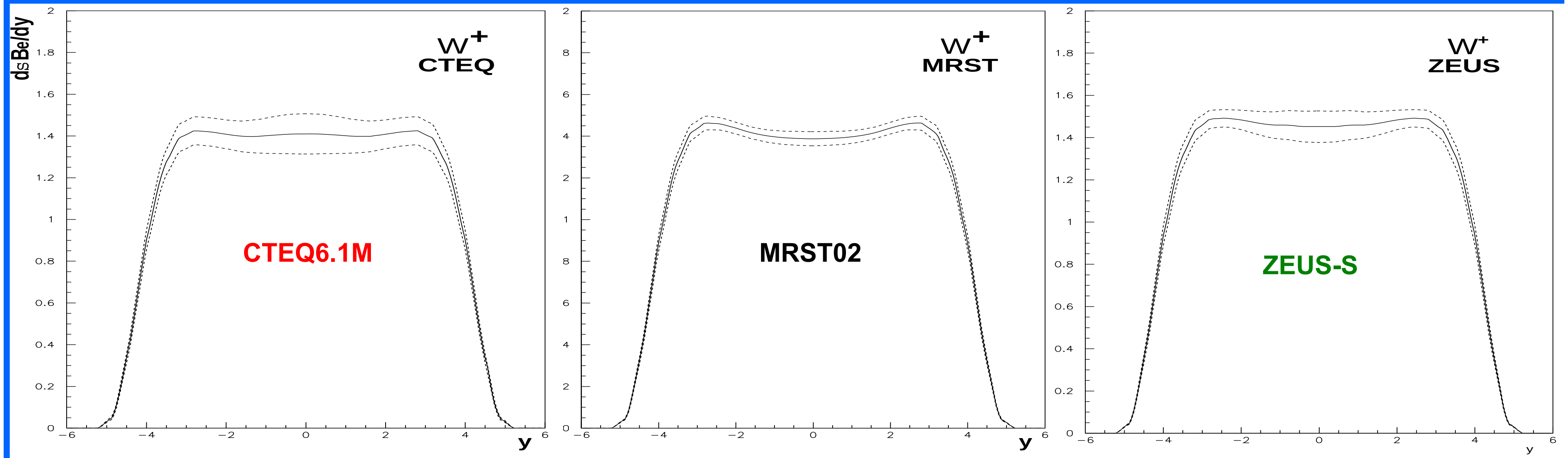
- ❑ At the LHC we will have dominantly **sea-sea** parton interactions at low-x
- ❑ And at $Q^2 \sim M^2_{W/Z}$ the sea is driven by the **gluon** by the flavour blind $g \rightarrow q\bar{q}$
- ❑ gluon is far less precisely determined for all x values

Measurement of W and Z rapidity distributions can increase our knowledge of the gluon PDF useful for many other measurements

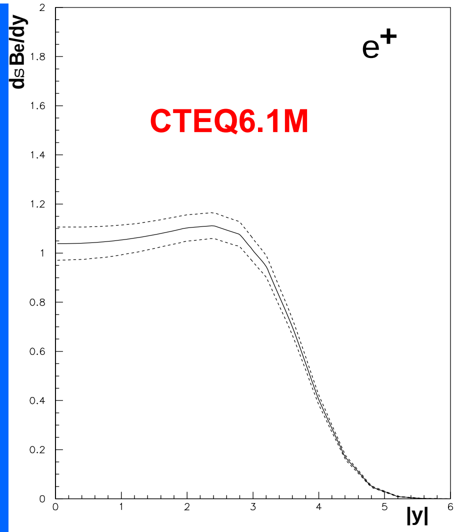


W and Z Rapidity Distributions for different PDFs

Analytic calculations: Error bands are the full PDF Uncertainties



At y=0 the total W PDF uncertainty is
~ ±5.2% from ZEUS-S
~ ±3.6% from MRST01E
~ ±8.7% from CTEQ6.1M
ZEUS to MRST01 central value difference ~5%
ZEUS to CTEQ6.1 central value difference ~3.5%
(From LHAPDF eigenvectors)



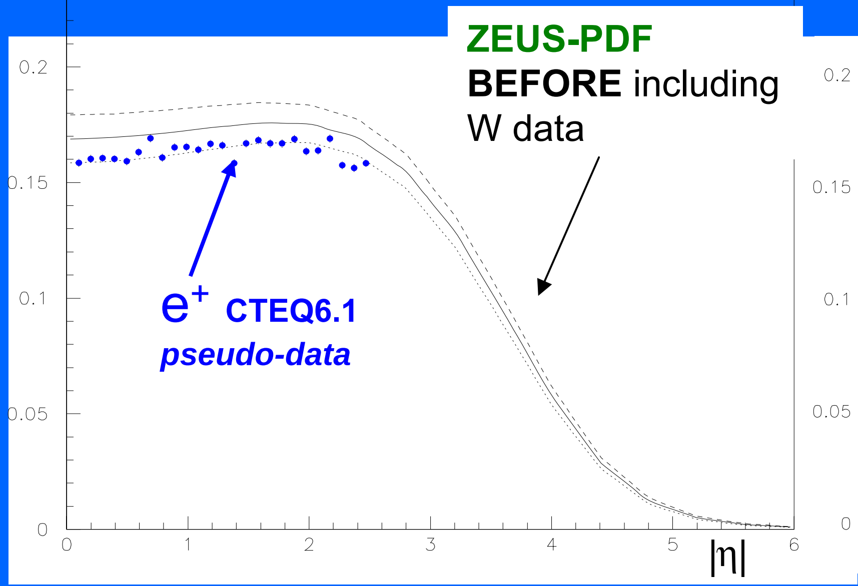
GOAL: syst. exp. error ~3-5%

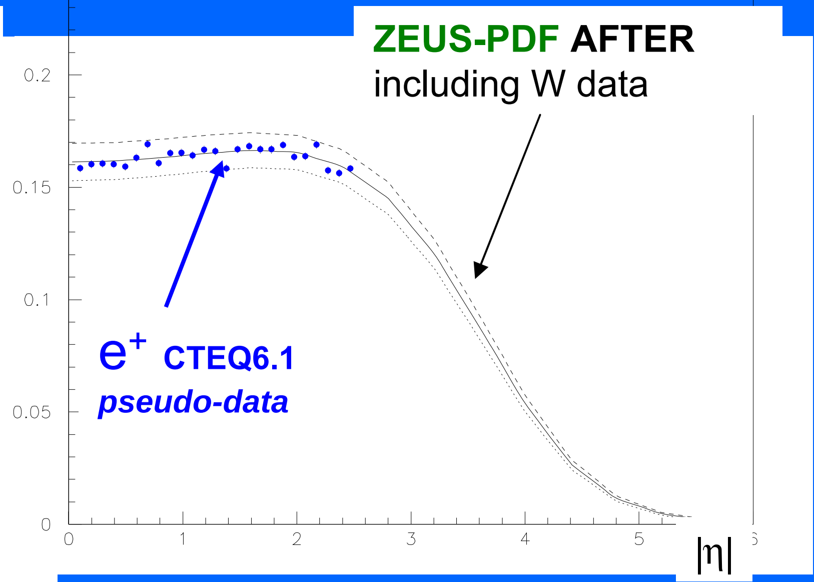
PDF constraining potential of ATLAS

Effect of including the ATLAS W Rapidity "pseudo-data" in global PDF Fits: how much can we *reduce the PDF errors* when LHC is up and running?

Simulate real experimental conditions:

Generate 1M "data" sample with **CTEQ6.1 PDF** through ATLFAST detector simulation and then include this *pseudo-data* (with imposed 4% error) in the global **ZEUS PDF fit** (with Det.->Gen. level correction).
Central value of ZEUS-PDF prediction shifts and uncertainty is reduced:





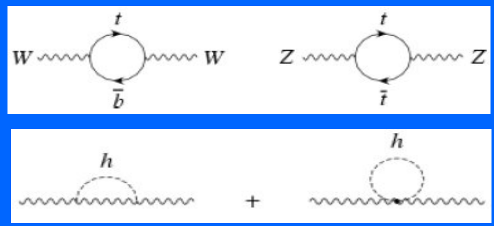
low-x gluon shape parameter λ, $xg(x) \sim x^{-\lambda}$:

BEFORE λ = -0.199 ± 0.046
AFTER λ = -0.181 ± 0.030
} 35% error reduction

NB: in ZEUS-PDF fit the $e^{\pm}$ Normalisation is left free => no assumption on Luminosity measurement

W mass and top mass

- M_W is a fundamental SM parameter linked to the top, Higgs masses and $\sin\theta_W$.



$$M_W = \sqrt{\frac{\pi\alpha_{EM}}{G_F\sqrt{2}}} \times \frac{1}{\sin\theta_W \sqrt{1-\Delta r}}$$

$f(M_t^2, \ln M_H)$

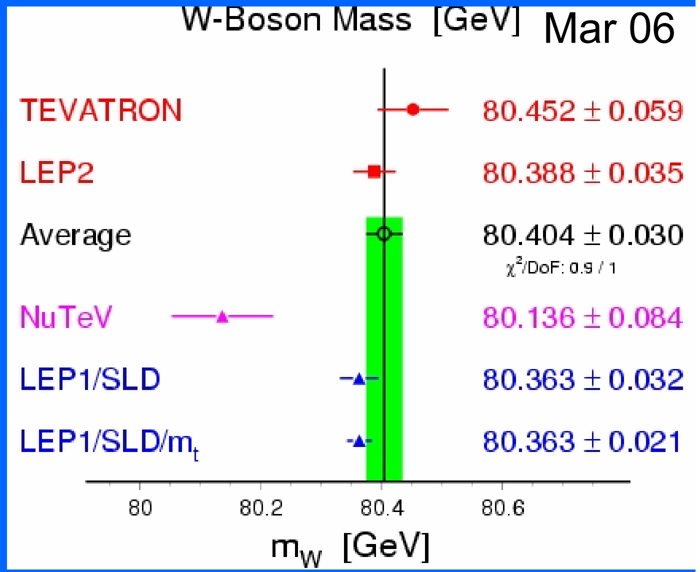
LEP2+Tevatron ΔM_W=30MeV
Tevatron run2 (2fb^{-1}) → 30MeV combined

- For equal contribution to M_H uncertainty:

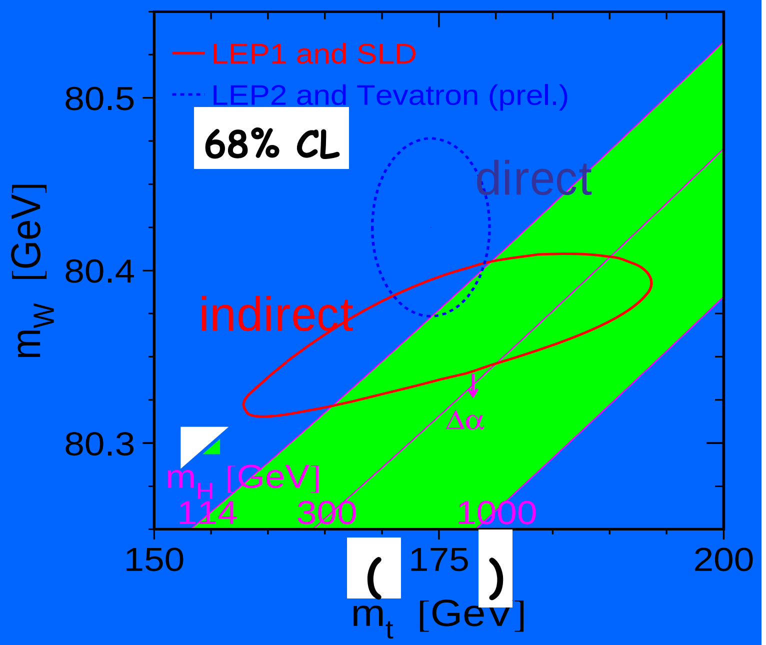
$$\Delta M_W \approx 0.7 \times 10^{-2} \Delta M_t$$

ΔM_t < 2 GeV → ΔM_W < 15 MeV

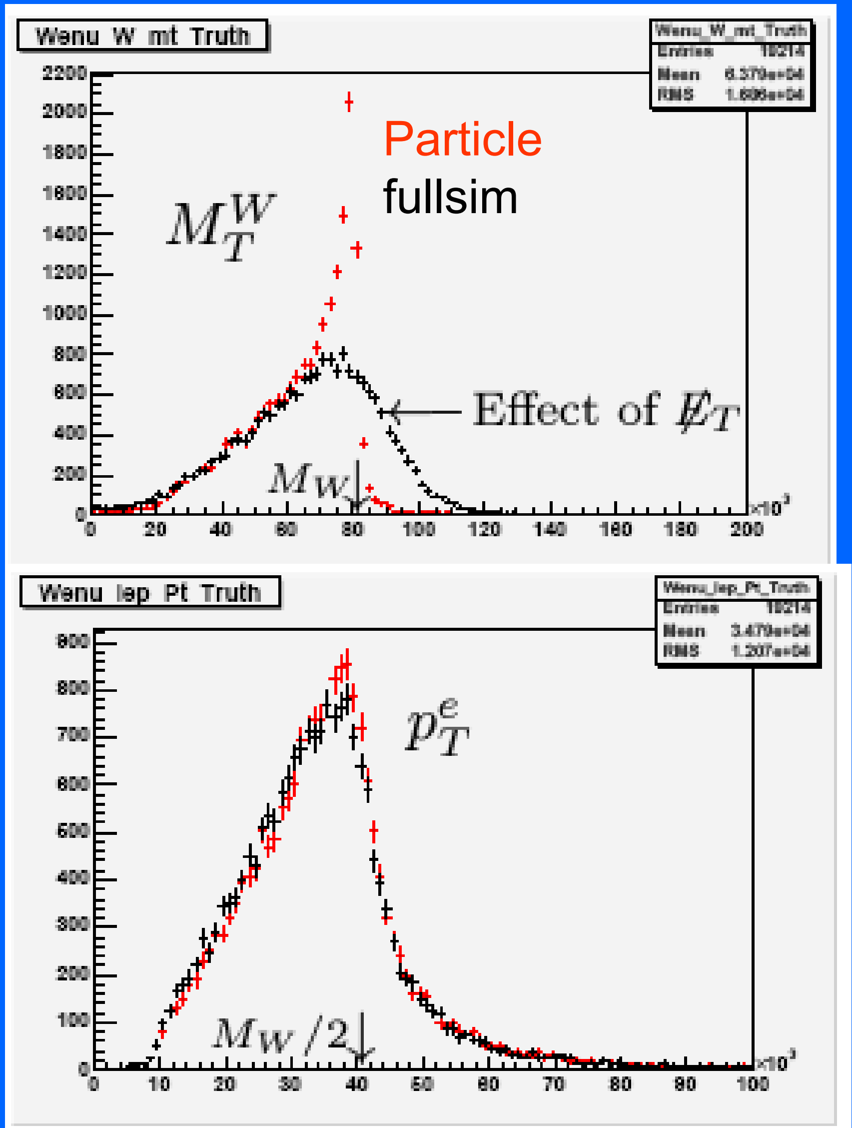
Can get $\delta M_H / M_H$~30%
Important cross-check with direct measurements



Summer 2005 result

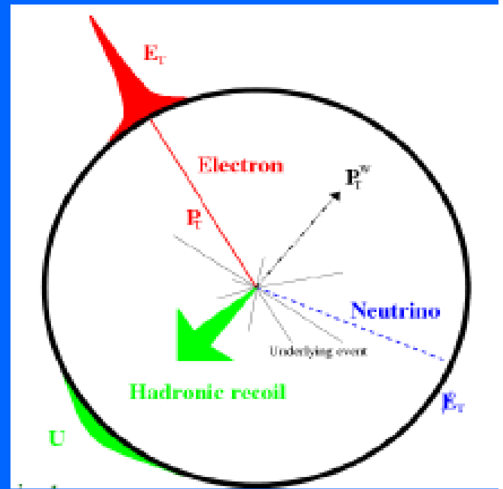


W-mass methods



$$M_T = \sqrt{2 p_T^l p_T^\nu \cos\phi_{l\nu}}$$

Sensitive to $\not{E}_T$



$p_T(l)$
Sensitive to Pt(W)

Selection of W events:

Isolated charged lepton p_T > 25 GeV $|\eta|$ < 2.4

Missing transverse energy E_T^{Miss} > 25 GeV

No jets with p_T > 30 GeV

Recoil < 20GeV

W-mass at $1fb^{-1}$

- Use Z events as templates
  - Scaled observable using weighting fn
  - Morphing using kinematic tranformation
  - Limited by Z-statistics
- Detector and theoretical effects cancel at least partially
- Pt(l) better than MT as it is not sensitive to E_T systematics
  - But needs $P_T(W)$ to be understood

	Scaled p_T(l) $W \to e\nu$ ΔM_W (MeV) $1fb^{-1}$ ($10fb^{-1}$)	"Morphed" m_T $W \to \mu\nu$ ΔM_W (MeV) $1fb^{-1}$ ($10fb^{-1}$)
Statistical	40 (15)	40 (15)
Instrumental	40 (<20)	64 (<30)
PDF	20 (<10)	20 (<10)
Γ_W	15 (<15)	10 (<10)
$P_T(W)$	30 (30)	--

- Based on $10fb^{-1}$ of data corresponding to ~10M $W \to l\nu$
- Fit $M_T(W)$ or p_T (e) to Z^0 tuned MC
- Z-Samples play a crucial role in reducing systematics
- Can get to ~15MeV/channel/expt

Source ΔM_W (MeV) $10fb^{-1}$	**$M_T^e(W)$**	**$P_T(e)$**
Statistics	**< 2**	**< 2**
Total Instrumental	**<20**	**<20**
p_T^W		**5**
Parton distribution functions	**3**	**3**
W width	**1**	**1**
Radiative decays	**10**	**10**

Dibosons

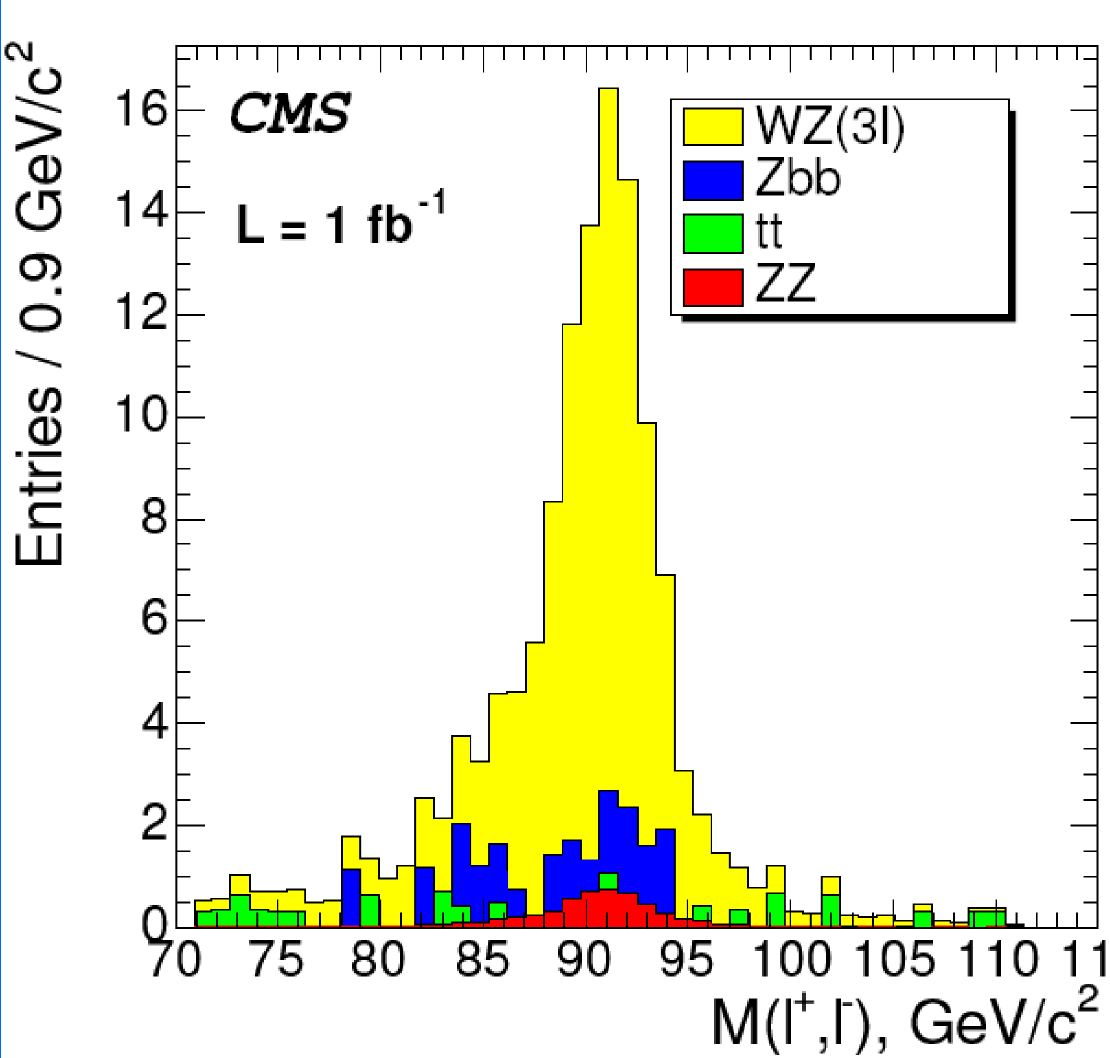
First measurements

For 1 fb^{-1}

$$WZ \ \frac{S}{\sqrt{B}} \sim 12$$ ~100 events

$$ZZ \ \frac{S}{\sqrt{B}} \sim 4$$ ~ 7 events

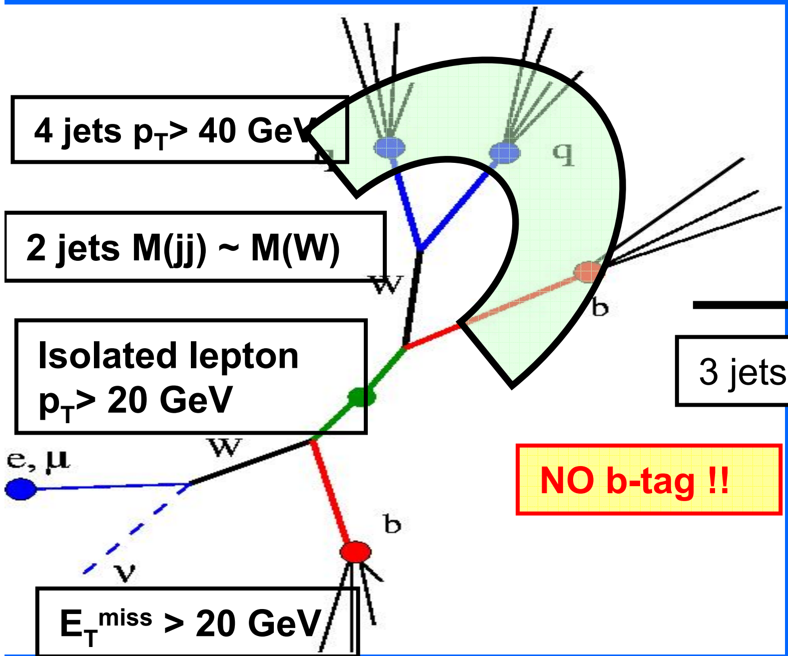
Inc systematics
→Background subtraction
→Lepton id and isolation

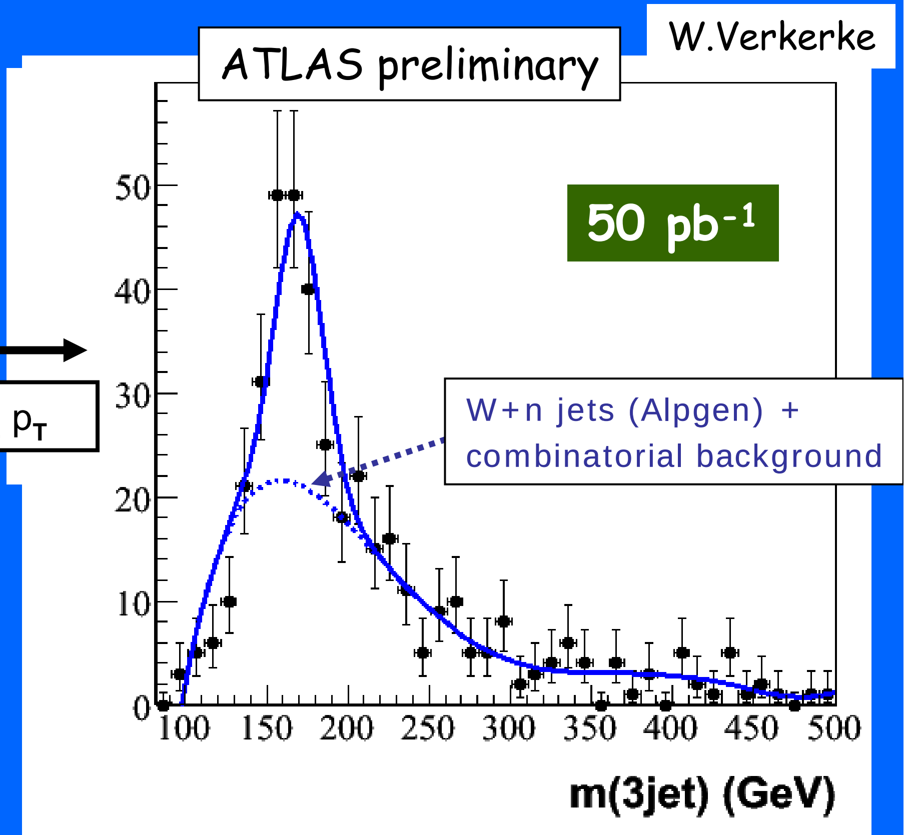


Early top measurements

Top

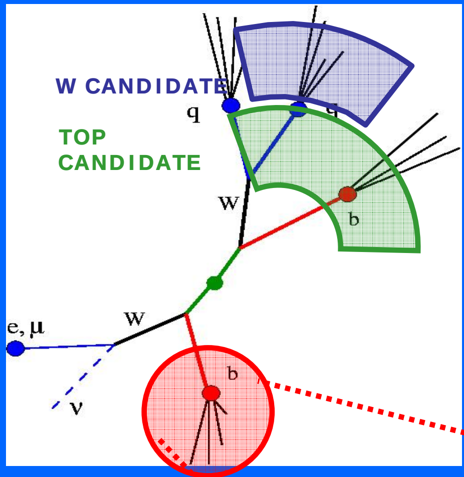
- Large σ_{tt} at LHC=250pb-1 for tt→jjb+lnub





Measure σ_{tt}~20% with 50pb-1
Measure mass to 10GeV with 100pb-1

Exploiting ttbar as b-jet sample

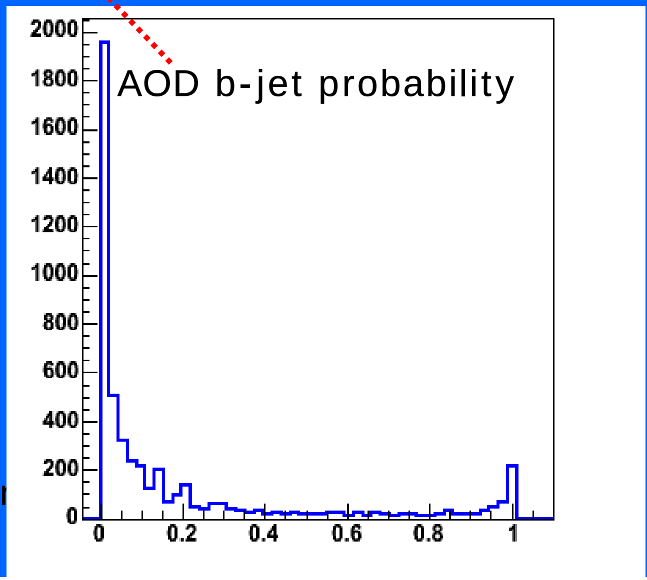


Simple demonstration use of ttbar sample to provide *b* enriched jet sample

- Cut on $m(W_{had})$ and $m(top_{had})$ masses
- Look at b-jet prob for 4th jet (must be b-jet if all assignments are correct)

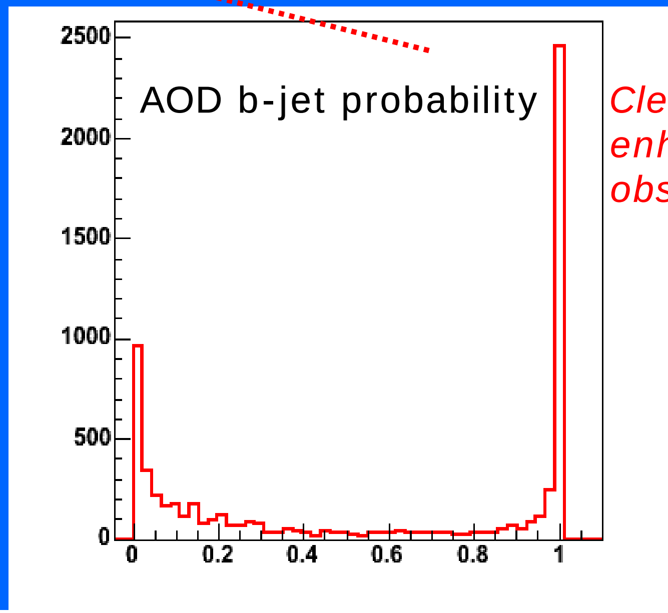
W+jets (background)

'random jet',
no b enhancement expected



ttbar (signal)

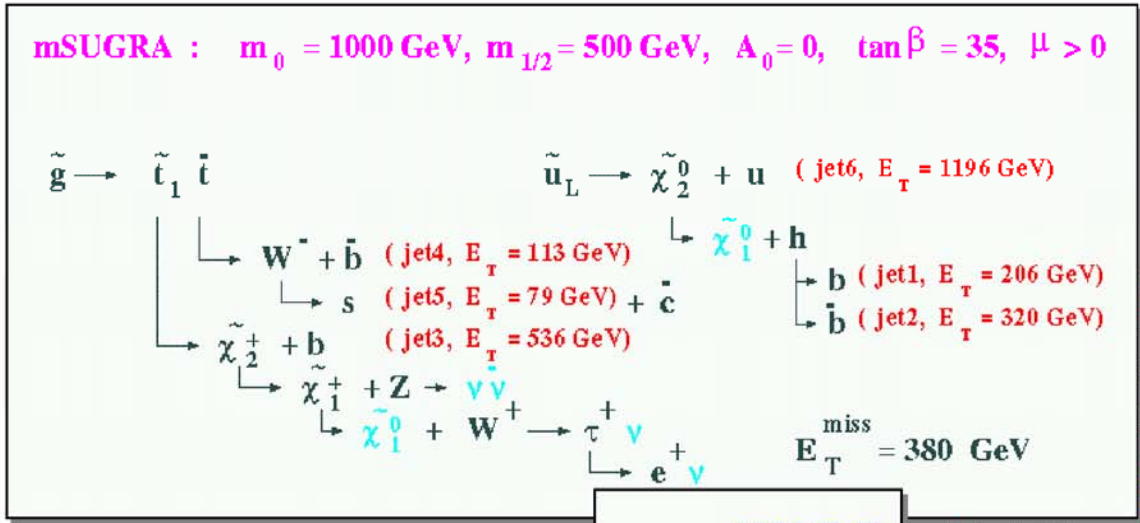
'always b jet if all jet assignment are OK'
b enrichment expected and observed



Clear enhancement observed!

Early SUSY

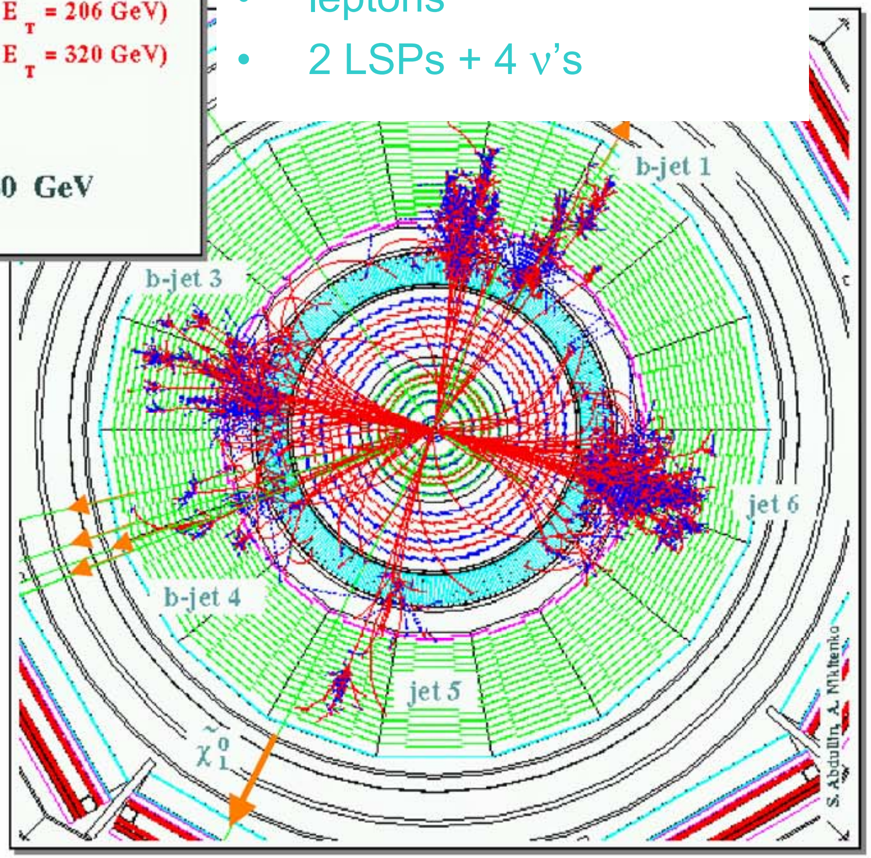
SUSY Signature: MET + Jets + …



4 hard b-jets
+2 hard jets

- 6 hard jets
- leptons
- 2 LSPs + 4 ν's

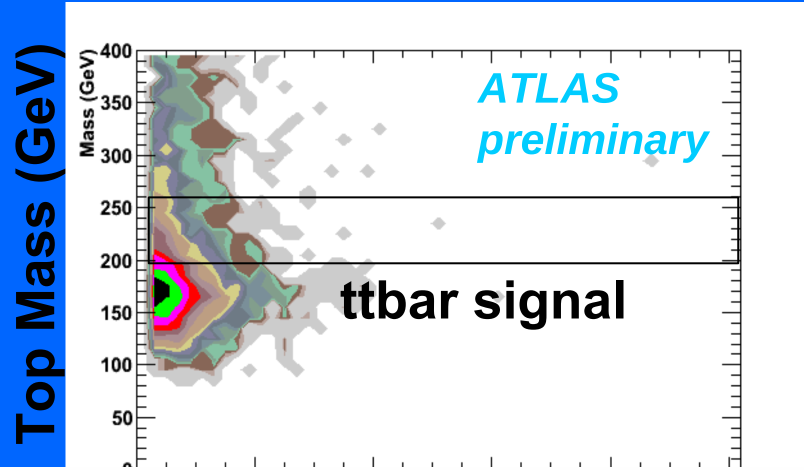
- $m_{\tilde{g}}$ = 1266 GeV
- $m_{\tilde{u}_L}$ = 1450 GeV
- $m_{\tilde{t}_1}$ = 1026 GeV
- $m_{\tilde{\chi}^0_2}$ = 410 GeV
- $m_{\tilde{\chi}^0_1}$ = 214 GeV
- m_h = 119 GeV

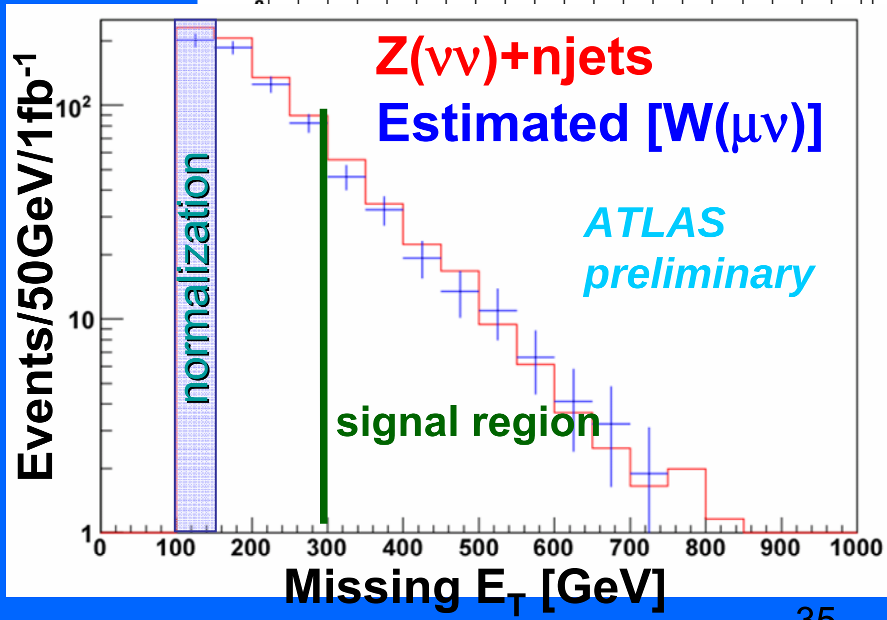


- Squark gluino production
- Full Geant4 Detector Simulation

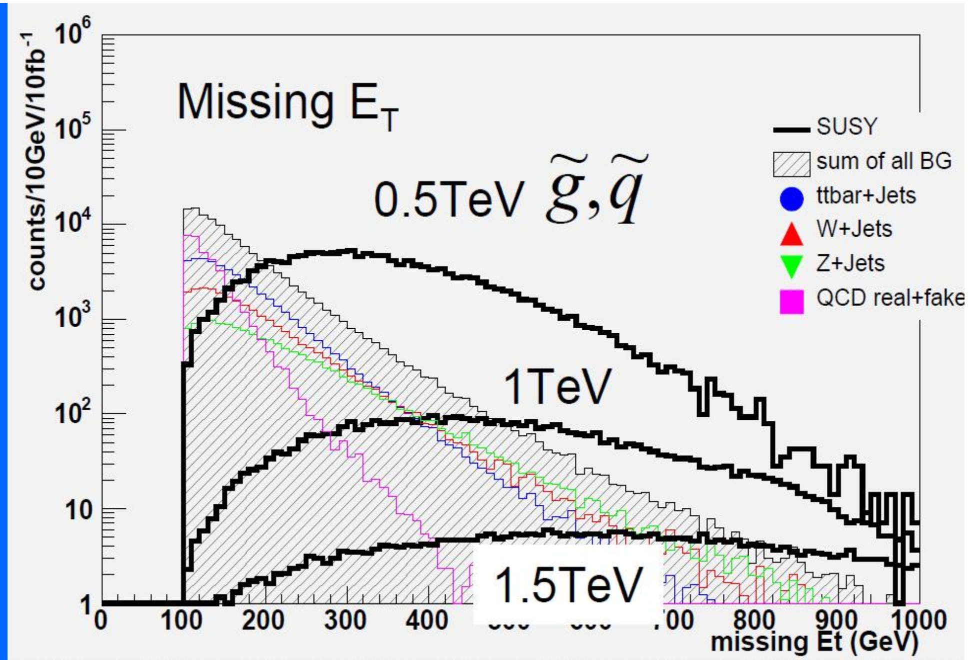
Early SUSY

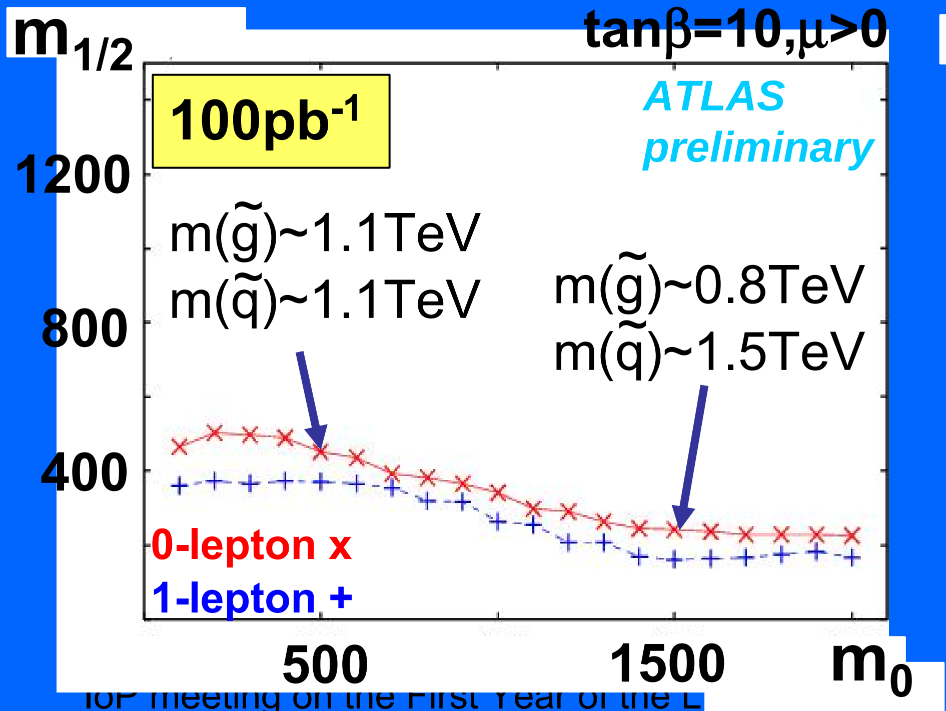
- Need to understand JES and ET-miss
- Evaluate backgrounds
  - Use PS+ME matching eg ALPGEN
  - Use tt sidebands and Wmunu to evaluate Et-miss
- Get Et-miss spectrum
  - Results in M0 and M1/2 plane
- MSusy < 1.1TeV for 100pb-1
- MSusy < 1.5TeV for 1fb-1

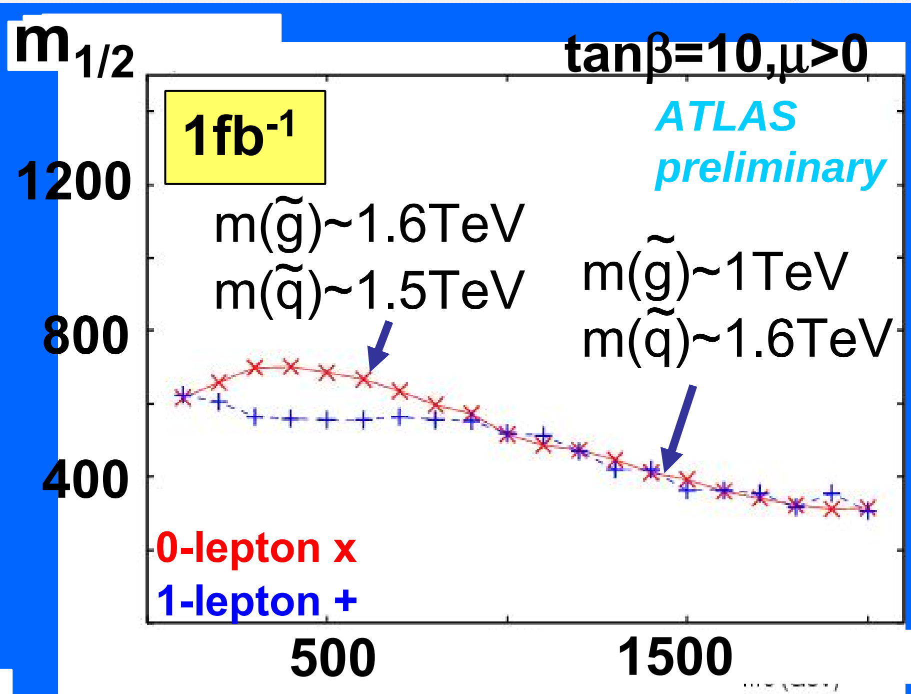




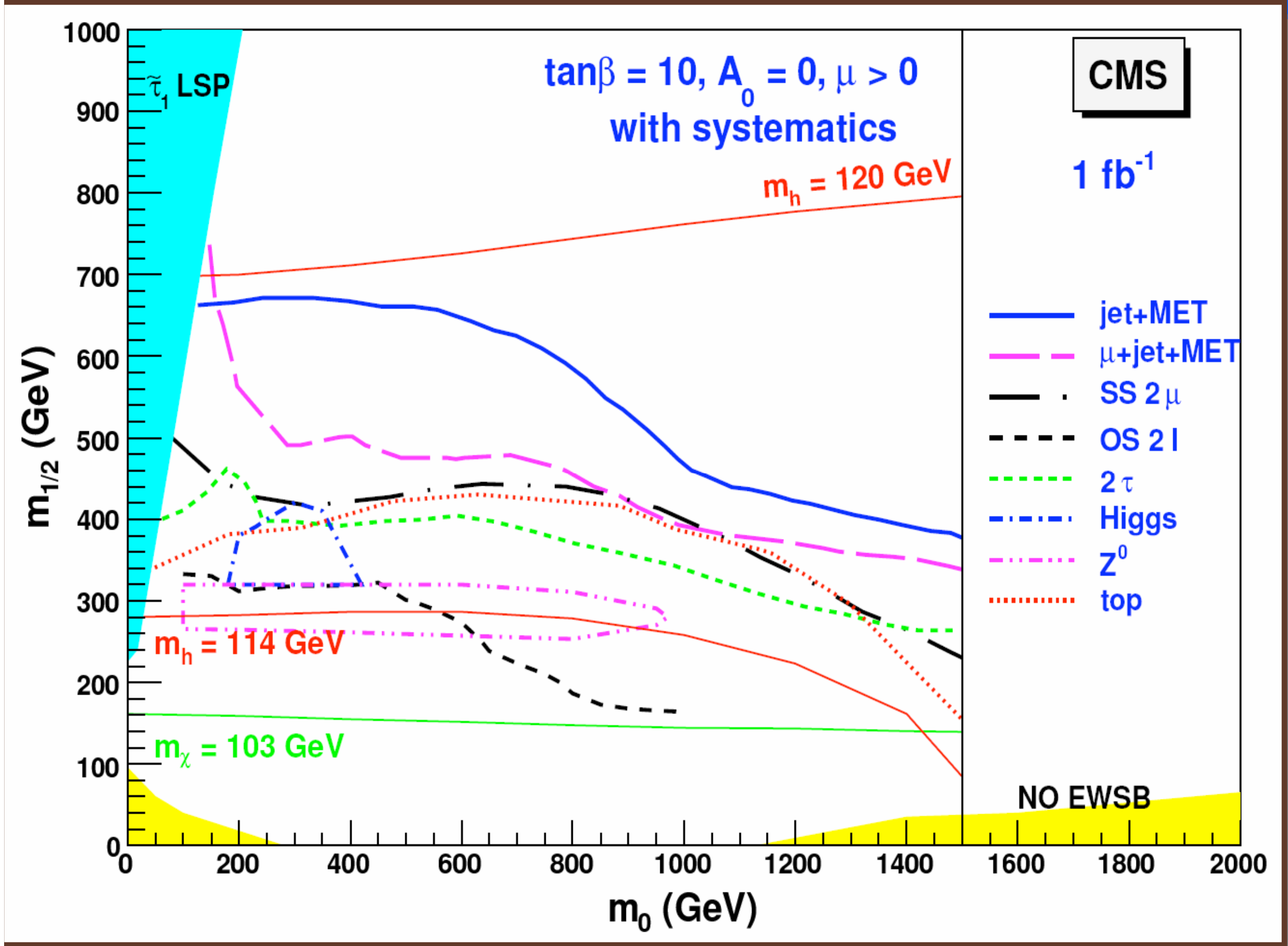
Inclusive jets+MET







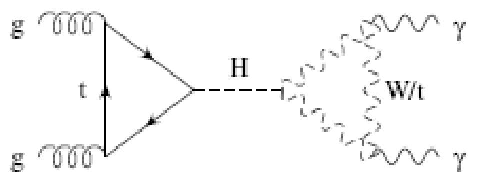
$1fb^{-1}$ SUSY reach

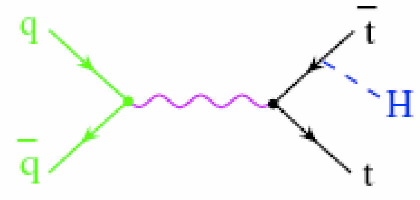


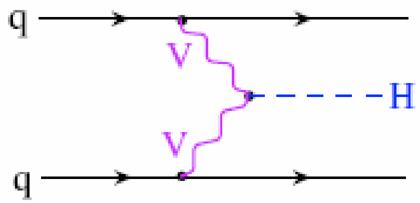
Inclusive searches

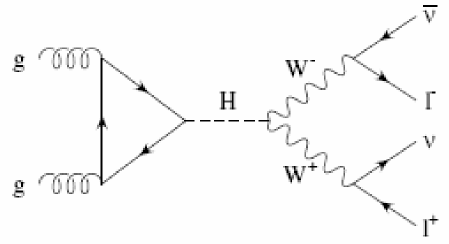
- jet +MET best limit
- Other channels can clarify SUSY model

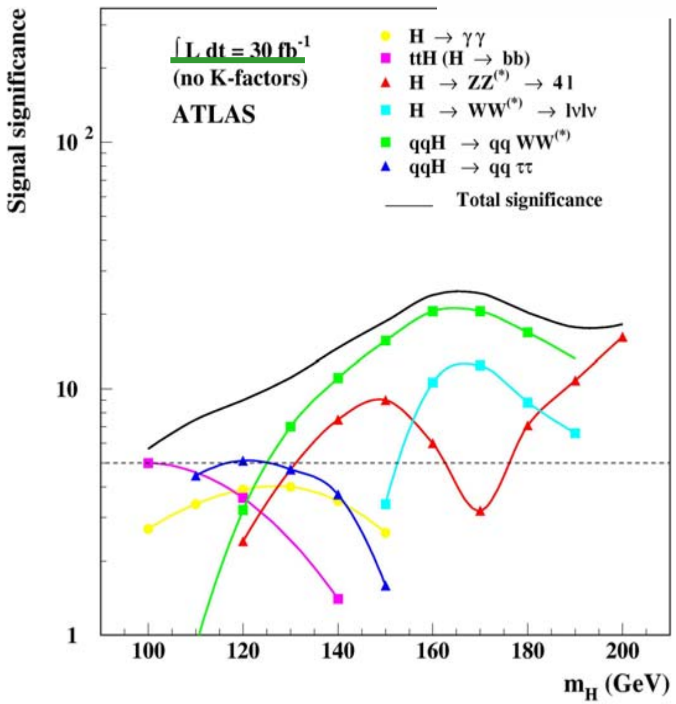
Higgs Discovery

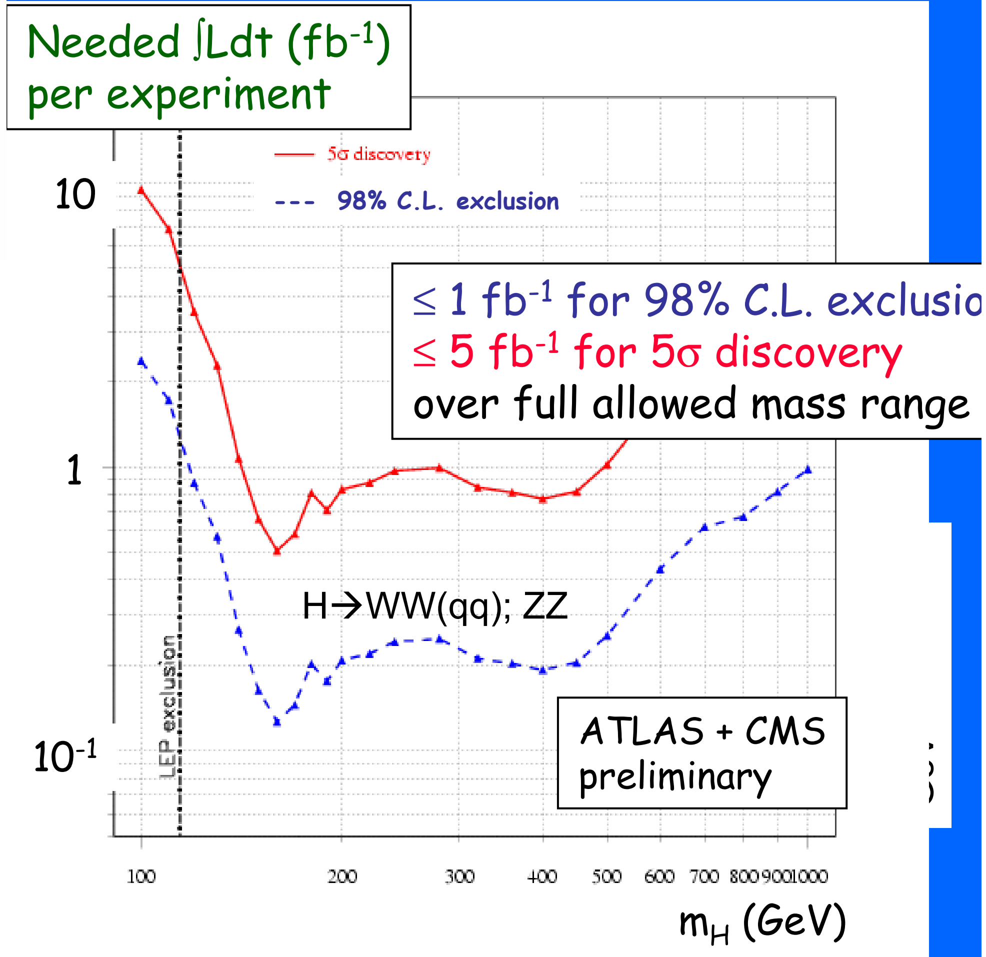








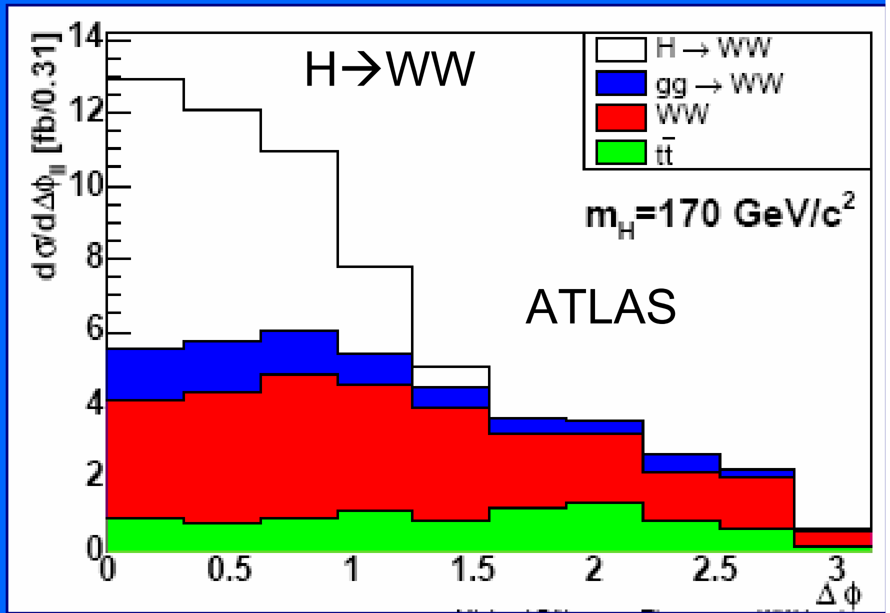




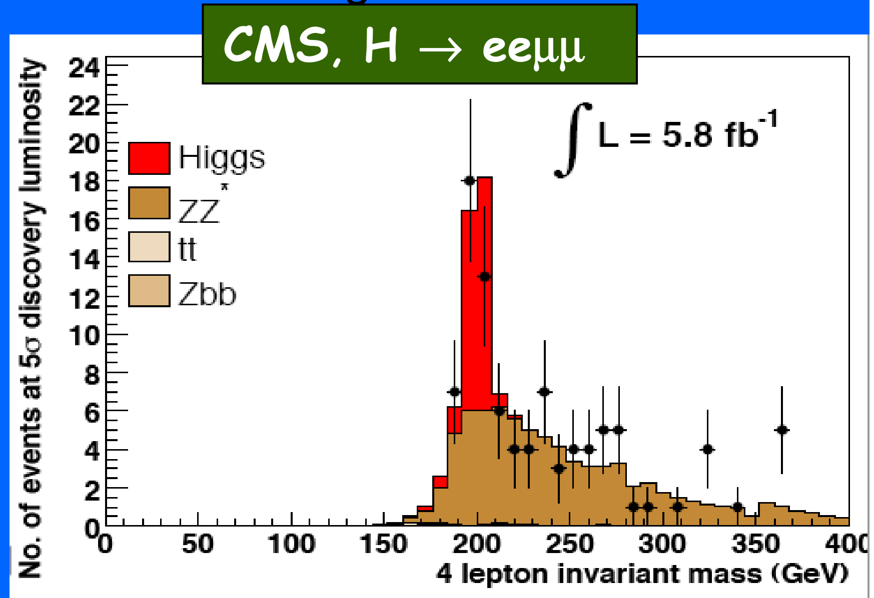
Higgs discovery is difficult → Focus on the indgredients!

Ingredients for Higgs discovery

- Early discovery is challenging
- H→WW (gg and VBF)
  - backgrounds: WW(+jets), tt(+jets)
  - Forward jet reconstruction
  - Central jet veto
- Golden Channel H→ZZ→4l
  - Maybe nature will be kind



Measure backgrounds in sidebands



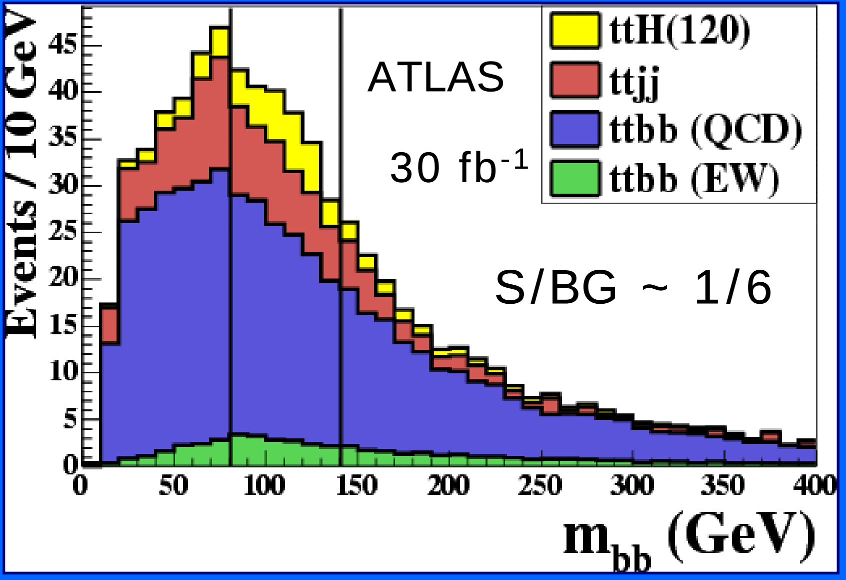
IoP meeting on the First Year of the LHC

Ingredients for Higgs discovery

- $H \rightarrow \gamma\gamma$ (high luminosity)
  - Jet rejection
  - Understanding pile-up ←min bias
- ttH (high luminosity)
  - b-tagging
  - t-reconstruction
  - Backgrounds: ttjj, ttbb
- $H \rightarrow \tau\tau$ (VBF)
  - Backgrounds

    τ reconstruction

- Backgrounds can be studied
  - ttjj, ttbb, …
- b-tagging optimised in top events
- Pile-up studied in MB events

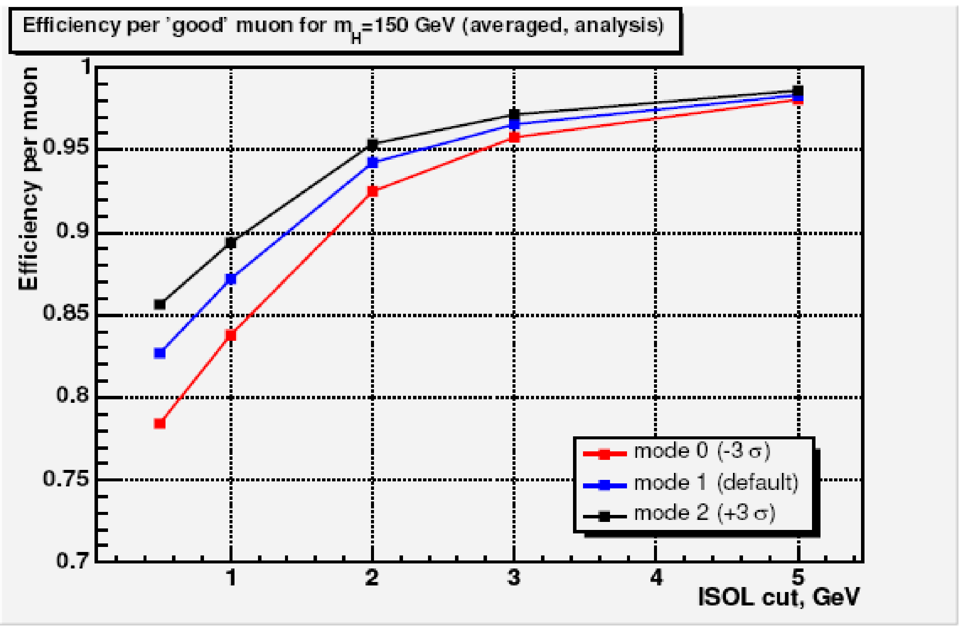


Lepton isolation in H->4μ

- Effect of UE on lepton efficiency
- Vary pt-min by 3σ
- Determine from data

- Good muons
  - Barrel η<1.1 Pt>7GeV
  - Endcap 1.1<η<2.4 P>9GeV
- Isolation

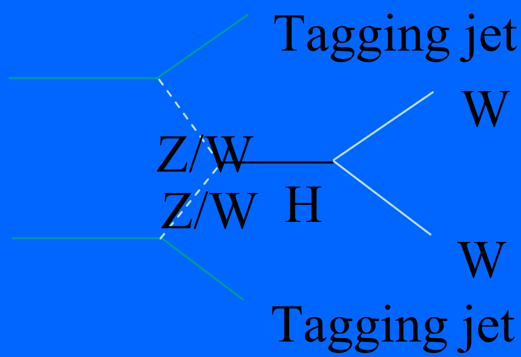
  ΣPt for charged tracks excluding μs with Pt>0.8GeV and ΔR<0.3 around μ in η-ϕ space

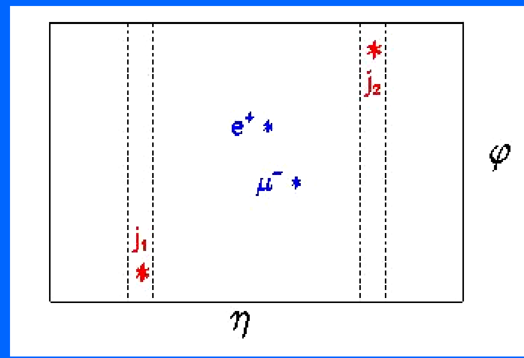


Process	Event eff Default	Event eff –3σ	Event eff +3σ
H→4μ MH=150GeV	0.775 ± 0.004	0.707 ± 0.005	0.812 ± 0.004
ZZ background	0.780 ± 0.004	0.721 ± 0.005	0.838 ± 0.004
4 random μ Z-inclusive	0.762 ± 0.007	0.706 ± 0.007	0.821 ±0.006

VBF Signal (H→WW→lνlν)

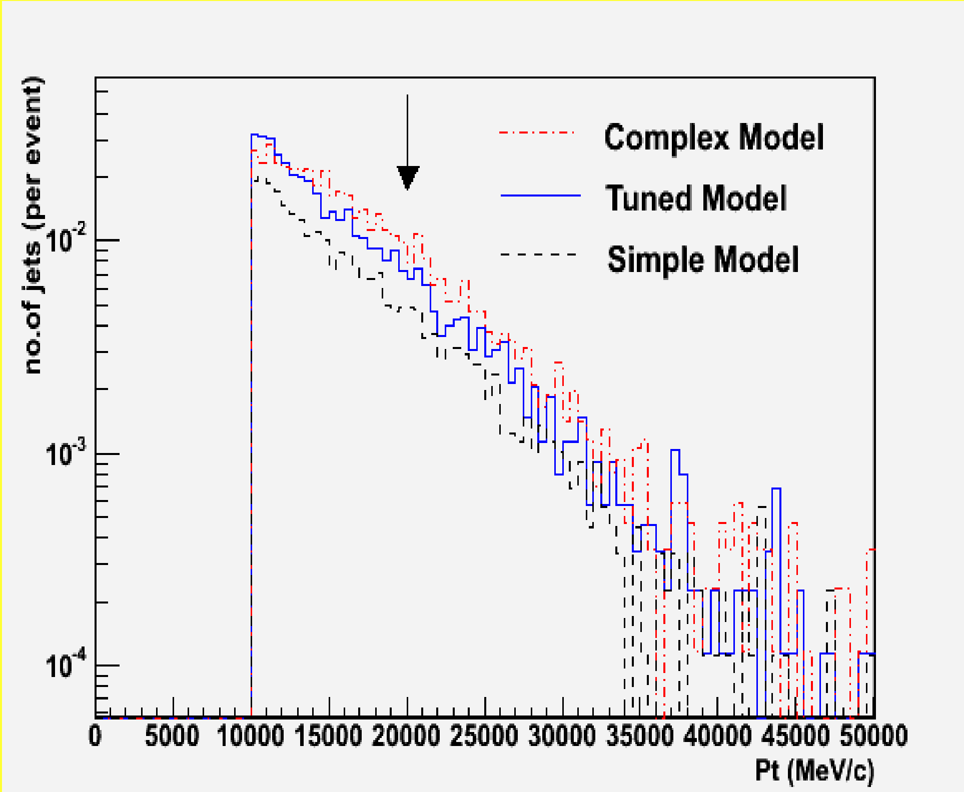
- forward tagging jets
- correlated isolated leptons
- **low hadronic activity in central region**
- central Higgs production





Important discovery channel
For Higgs in mass range
120-200GeV

Model	Parameter
Simple	MSTP(82)=1 PARP(81)=1.9
Complex	MSTP(82)=4 PARP(82)=1.9
Tuned	MSTP(82)=4 PARP(82)=1.8 PARP(84)=0.5



Model	CJV (eff)	LEPACC (eff)	All Vetoes (eff)
Simple	0.943 ± 0.003	0.610 ±0.001	0.084 ±0.001
Complex	0.885 ± 0.003	0.575 ±0.001	0.076 ±0.001
Tuned	0.915 ± 0.003	0.589 ±0.001	0.080 ±0.001

Uncertainty at the level of ~6% on CJV Pt>20GeV and ~3% on lepton
Giving a total uncertaintly in the range ~8%

Summary (not exhaustive!) at $1fb^{-1}$

- Minimum bias
  - dN/deta~10%
- Underlying event
  - Particle density and $p_t$sum ~10%
- Azimuthal decorrelations
  - Tune monte carlos
- Inclusive jets
  - 2 TeV jets, probe new physics BUT need to understand PDFs
- W,Z production
  - Cross-sections ~3%
  - Calculate lumi ~ 6-7%
  - Need to understand PDFs better
  - M_W measured to ~40MeV
- Dibosons
  - 10s of events
- Top
  - Top mass measured to ~10GeV $\sigma(tt)$~20%
- Higgs
  - Need well understood detector
  - Golden channel of H→ZZ→4l
  - Background studies
- SUSY
  - Sensitive to SUSY ~1TeV
  - Etmiss studies
  - Background estimates

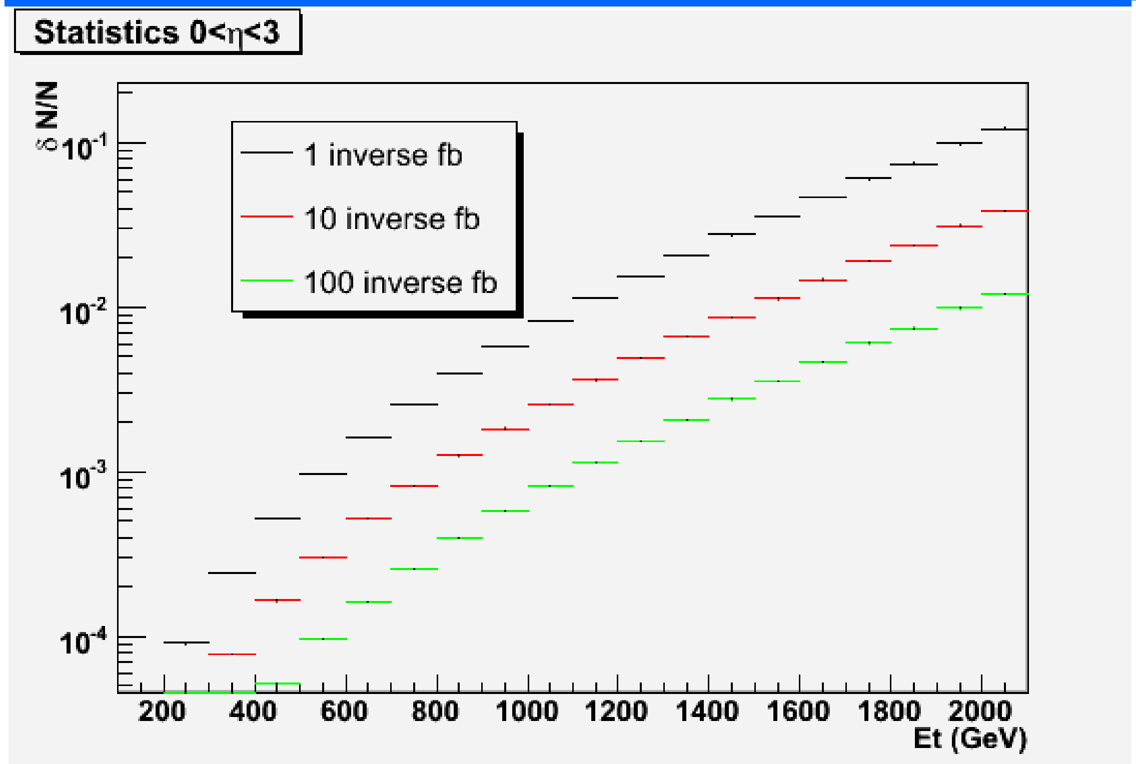
Good references:
CMS Physics TDR
ATLAS Physics TDR (→ CSC notes)
CMS+ATLAS Scientific notes

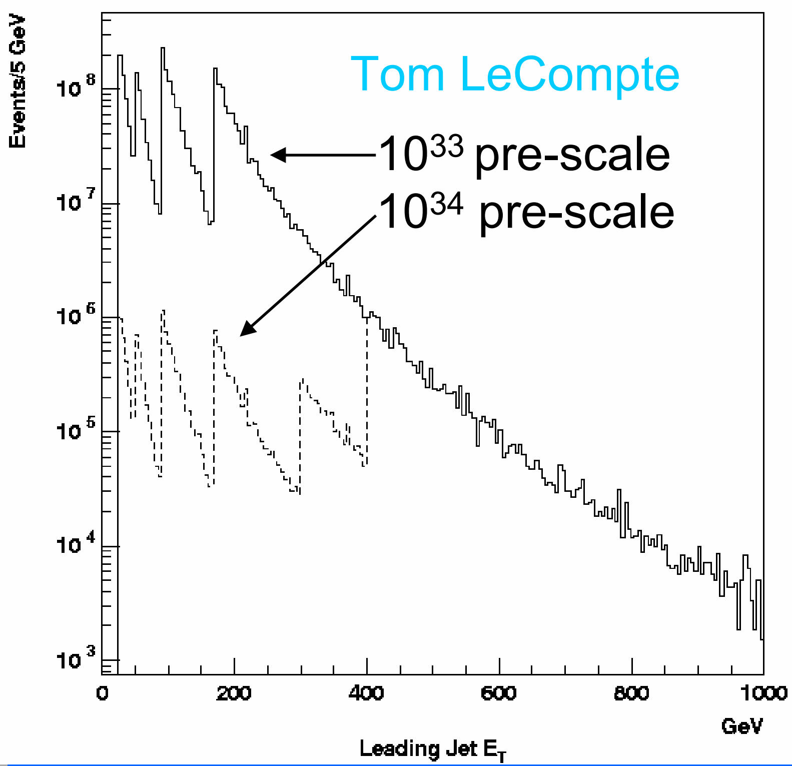
Summary

- Lots of interesting physics to do with $1fb^{-1}$
- Rediscover the standard model
  - Crucial for searches
  - Evaluate backgrounds for Higgs and new physics
- Can make limited top measurements
  - Crucial for backgrounds and commissioning
- SUSY
  - Inclusive measurements are sensitive to ~1TeV
  - Robust method to evaluate MET and backgrounds from data being developed
- Higgs
  - Not easy to see with $1fb^{-1}$
  - Evaluate backgrounds and understand the detector
  - Maybe see the “golden channel”

Extra slides

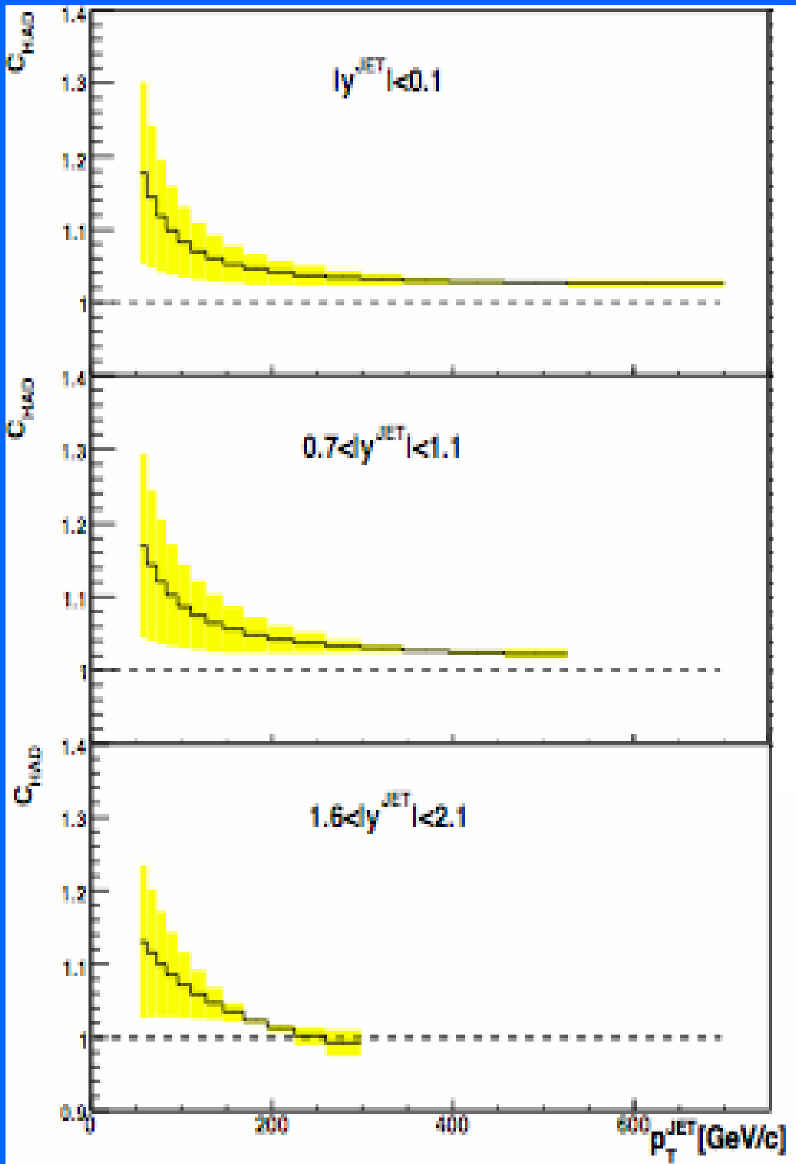
Statistical Errors





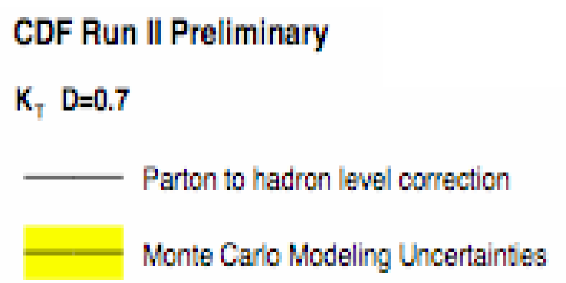
Statistical errors are negligible
but need to be trigger aware! -- pre-scales need to be included

CDF k_T



To make comparisons with calculation, include correction for non-perturbative contributions

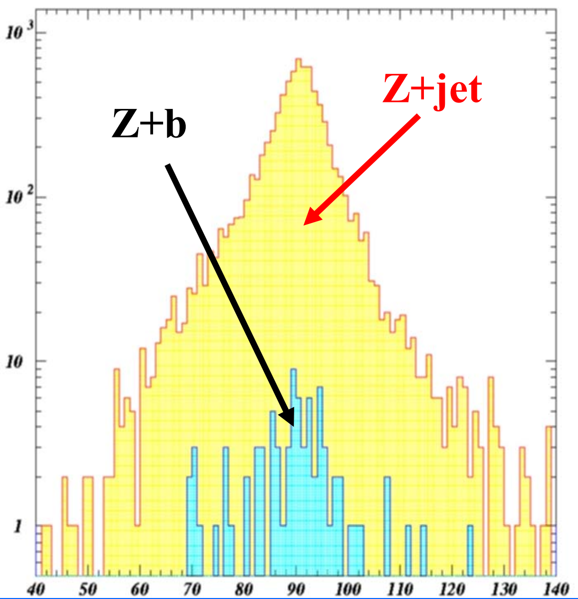
– estimated by turning on/off fragmentation, interactions with beam remnants.



Z + b-jets

- **Motivation:**
- Sensitive to b content of proton *(J.Campbell et al. Phys.Rev.D69:074021,2004)*
  - → **PDF differences in total Z+b cross section 5% → 10% *(CTEQ, MRST, Alehkin)***
- Background to Higgs searches *(J.Campbell et al. Phys.Rev.D67:095002,2003)*
- bb→Z is ~5% of Z production at LHC.
- **$Z \rightarrow \mu^+\mu^-$ channel**
  - → Full detector reconstruction.
  - → Two isolated muons (Pt > 20 GeV/c, opposite charge, inv. mass close to Mz)
  - → Inclusive b-tagging of jet: Z+ b selection efficiency ~15%; purity ~53%
- Z+b measurements will be possible with ~30fb^{-1} but systematics must be controlled: luminosity and jet reconstruction/energy scale, b-tagging
- Can also be looked at as calibration channel
  → see other talks in this session

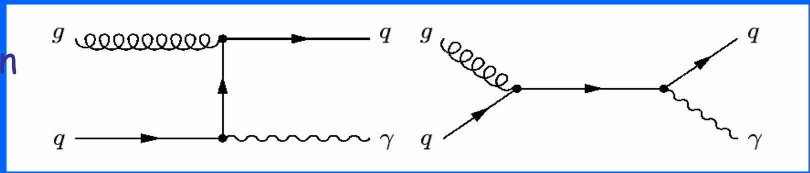
Di-muon invariant mass



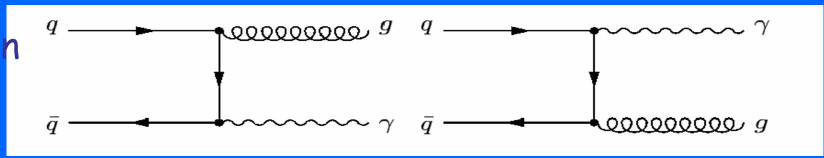
Direct γ production

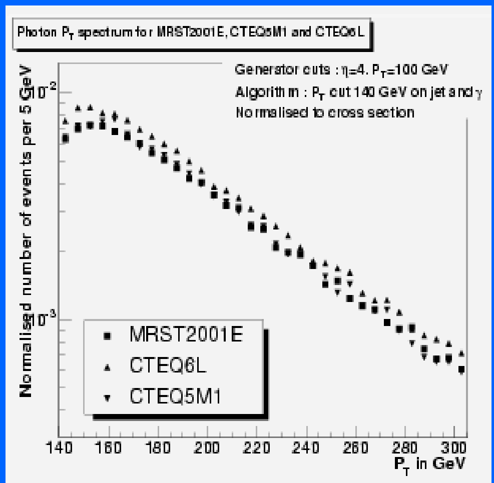
I.Hollins, Birmingham

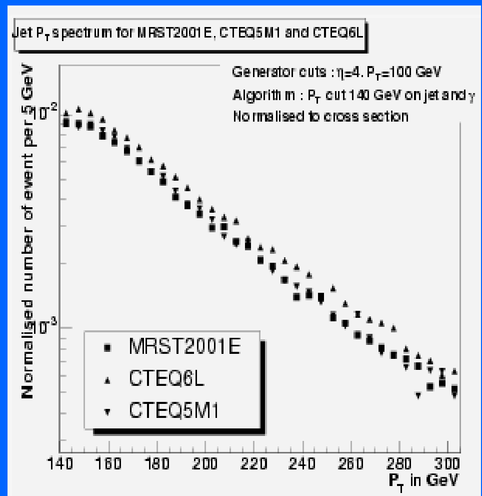
Compton
~90%

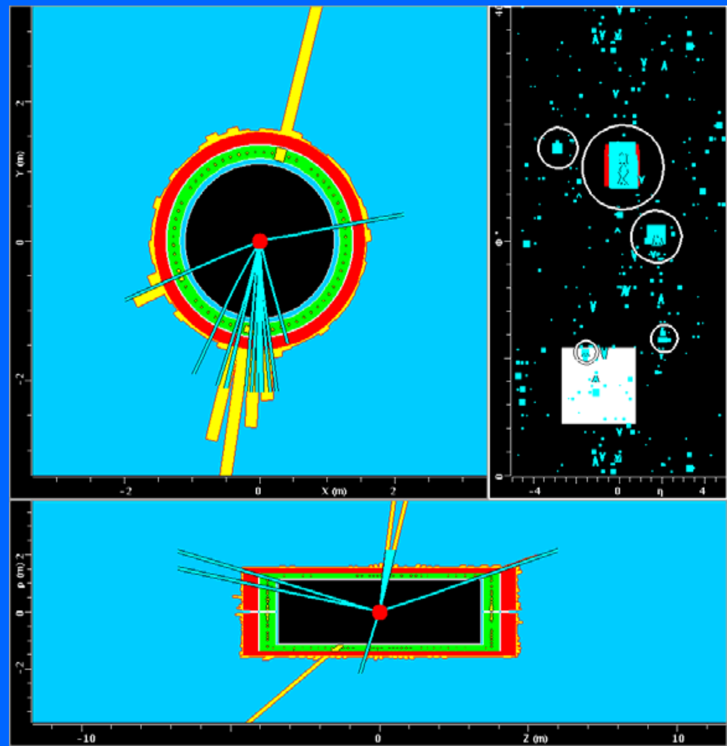


Annihilation
~10%









- Differences between CTEQ6L and MRST01E give ~16-18% differences on *jet* and γ p_T distributions
- Studies ongoing to evaluate experimental uncertainties (photon identification, fake photon rejection, backgrounds etc.)

W-mass summary

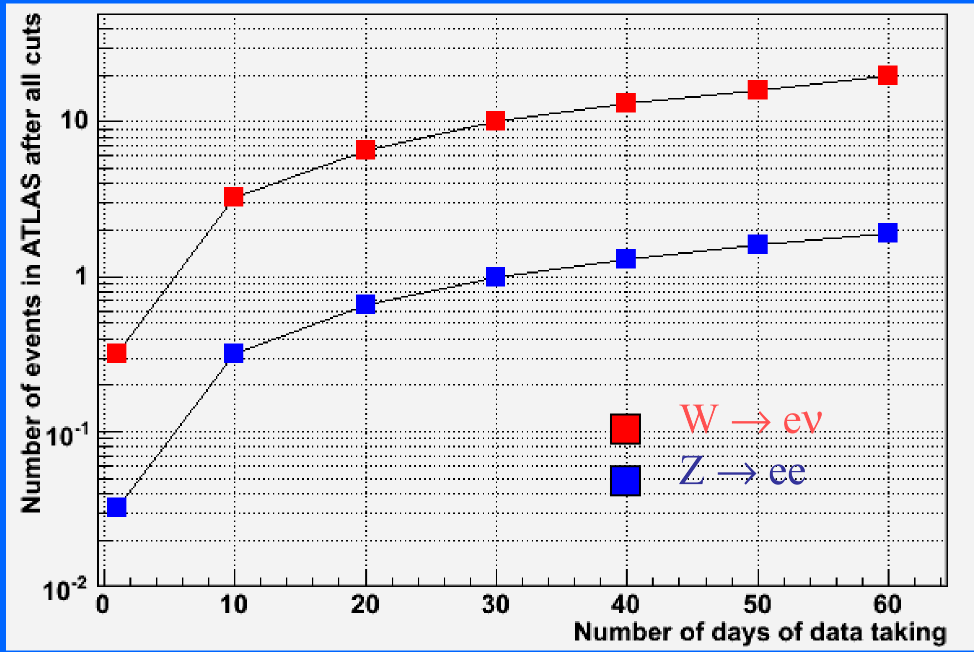
- A number of methods have been studied
  - Direct measurement of M_T $p_T(l)$
    - Z-events used to tune W MC
  - scaled observable pt(l), ‘morphing’
    - Z-events used as a template
  - Systematics greatly improved using Z-samples
  - All methods are giving ΔM_w in range of 20MeV per channel per variable, so combined <15MeV per experiment seems to be achievable for $10fb^{-1}$
    - Need to understand correlations
    - Main issues at $\not{E}_T$ for M_T and $P_T(W)$ for $p_t(l)$

      ΔM_W ~10MeV looks possible
    - Requires ΔM_t<1GeV for EW fits

Reality: running in 2007

- 900 GeV cm
- Lumi~$10^{29}cm^{-2}s^{-1}$
- pp kills W, Z production
- Below tt production scale

- Focus on detector commissioning with:
  - Minimum bias
  - Jets
  - J/ψ and ϒs



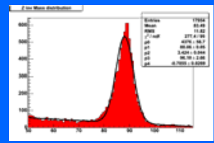
F.Gianotti June06

e trigger efficiency from data Z->ee

a) Run the HLT trigger chain and store events offline. Determine the number of Z by a fitting procedure (after reconstruction).

SINGLE TRIGGER : e25i

Trigger → offline →



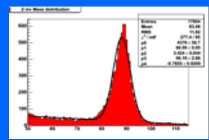
-Diagnostic sample-

⇨ N_1^z events

b) Tag (online) the events for which we have 2 or more clusters satisfying the e25i cuts

DOUBLE TAG: 2e25i

Trigger → offline →



-Tagged sample-

⇨ N_2^z events

$$N_1^z = \varepsilon_z^{rec}\left(2\varepsilon_e^{trig} - \varepsilon_e^{trig^2}\right)N_0^z + B_1$$

$$N_2^z = \varepsilon_z^{rec}\varepsilon_e^{trig^2} N_0^z + B_2$$

$$\varepsilon^{trig} = \frac{2\,(N_2^z - B_2)}{(N_2^z - B_2) + (N_1^z - B_1)}$$

Trigger efficiency : electrons

$$R = \sigma \cdot L \cdot (2\varepsilon - \varepsilon^2) \cdot A_Z \cdot \varepsilon_Z$$

$$\sigma_{zee} = 1.87 \cdot 10^{-33} cm^2$$

$$L = 10^{31} cm^{-2} s^{-1}$$

$A_Z.\varepsilon_Z \approx 12\%$ Acceptance.Reconstruction eff.

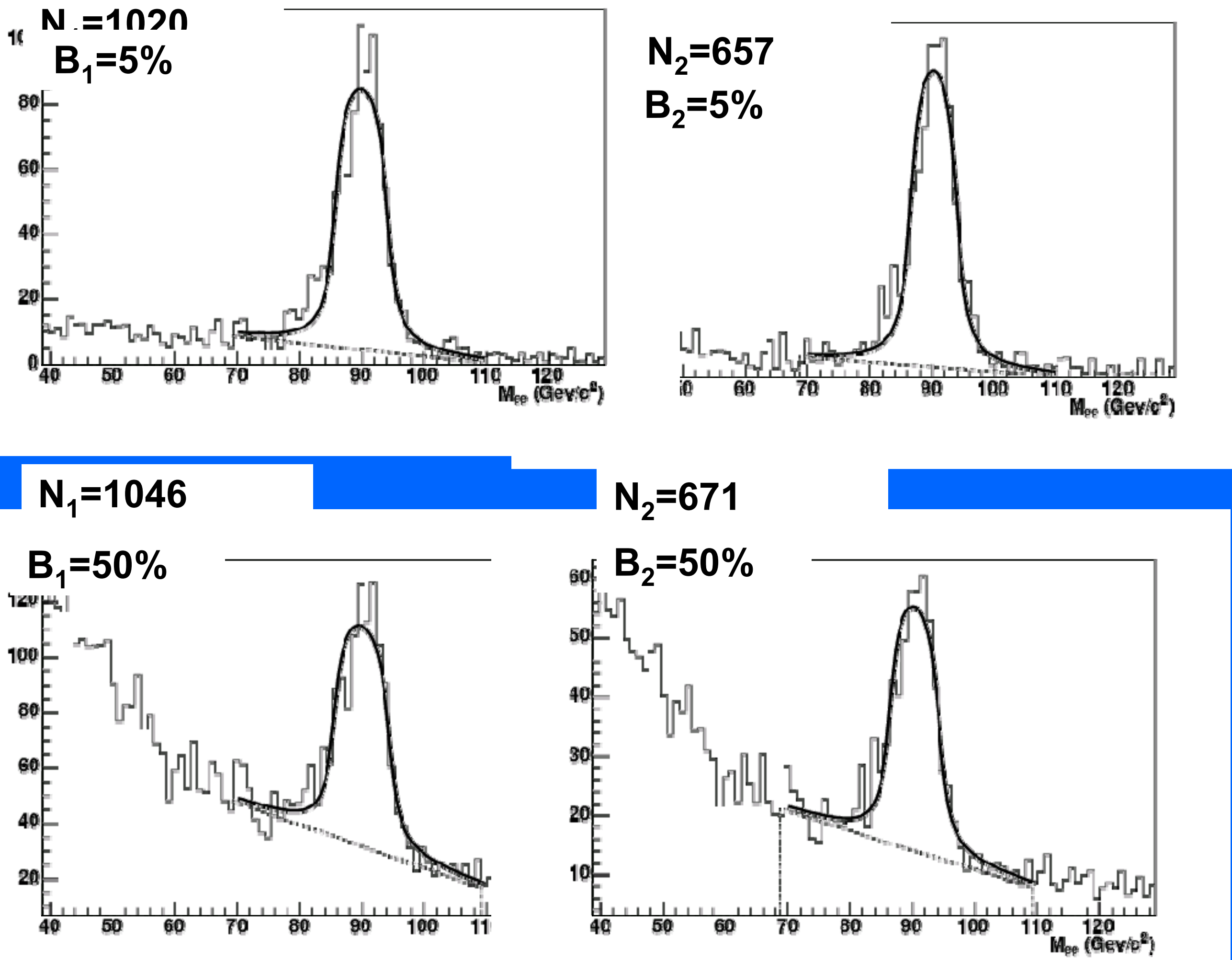
$\varepsilon \approx 87\%$ HLT single electron trigger efficiency

$$R \approx 2.2 \text{ mHz}$$

$$\frac{\sigma_\epsilon^2}{\epsilon^2} = \frac{(2-\epsilon)^2}{2} \frac{(1-\epsilon)}{\epsilon} \frac{1}{2N_1}$$

Statistical uncertainty	Time $\varepsilon \approx 87\%$	Time $\varepsilon \approx 60\%$
1%	5 days	34 days
2%	30 hours	8.6 days
3%	13.5 h.	3.8 days
5%	5 hours	33 hours
10%	72 min	8.3 hours
20%	20 min	2 hours

Impact of background uncertainty



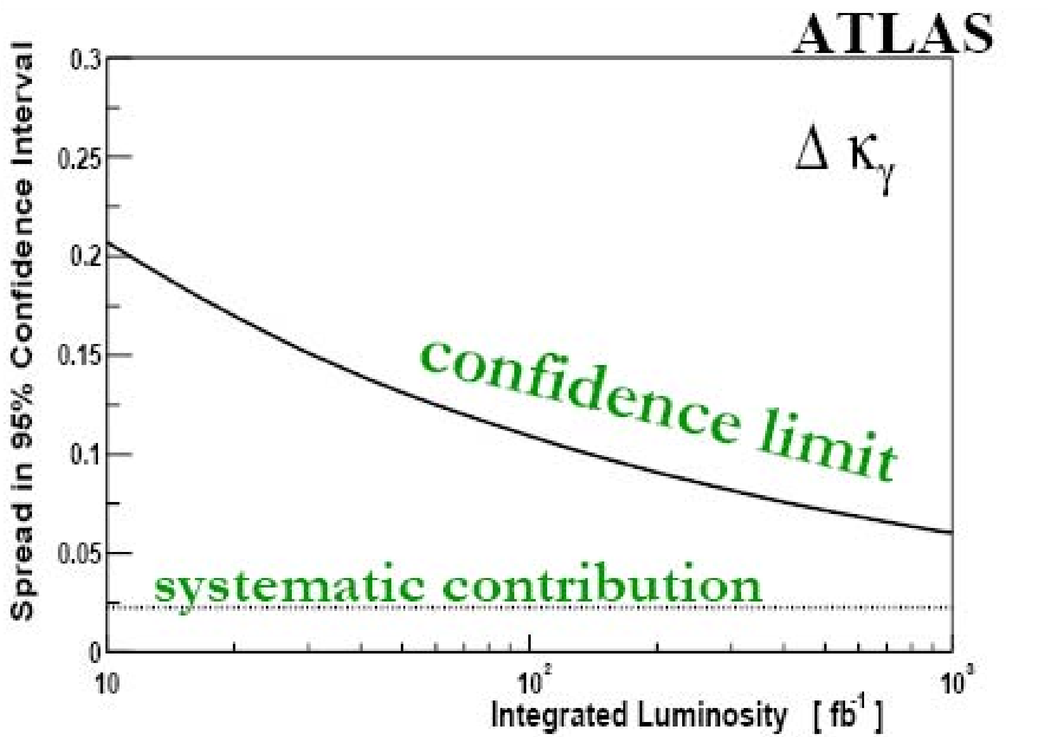
The same amount of background (QCD dijets) was added to both the diagnostic and tagged sample for different arbitrary background levels (5%, 20, 50%).

The calculated efficiency was statistically compatible in each case.

Systematic contribution 1 order of magnitude smaller than statistical one.

TGC Limits vs. Integrated Luminosity

95% C.L., 30 fb^{-1}, Syst. Incl.
$-0.0035 < \lambda_\gamma < +0.0035$
$-0.0073 < \lambda_Z < +0.0073$
$-0.075 < \Delta\kappa_\gamma < +0.076$
$-0.11 < \Delta\kappa_Z < +0.12$
$-0.0086 < \Delta g^1_Z < 0.011$



- typically order of magnitude better than LEP/TeVa [$\mathcal{O}$(.10-.20), 95% C.L.]
- Statistics will dominate LHC measurements (except for Δg^1)
  - →sensitivity derived from a few events in the high $P_T(V)$ tail
- Dominant systematics are theoretical:
  - →neglected higher orders and pdf's

EM energy scale from Z→ee

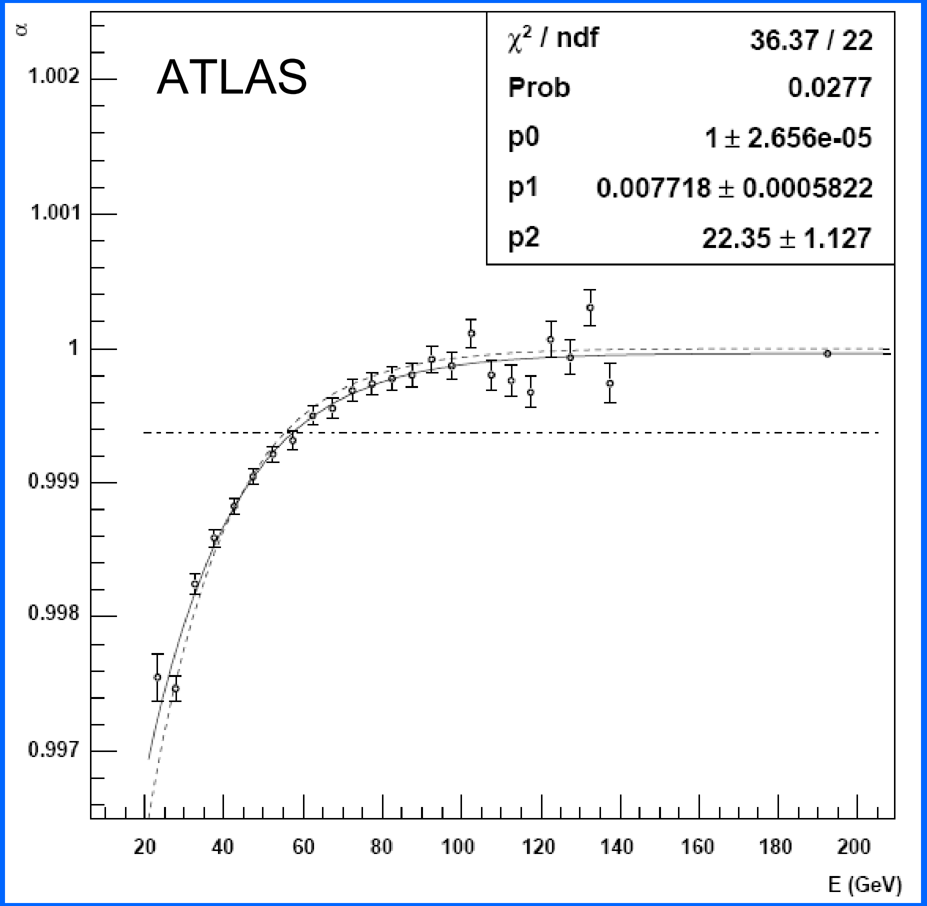
Energy scale reconstructed from fit to Z-peak

Binned in 5GeV bins from 20-140GeV

From 10fb^{-1} Z→ee for data σ(scale)=1.9x10^{-4}

ΔM_W~4MeV
(initial estimate of 10MeV)
Binning in energy improve extrapolation from Z→W

Based on calorimeter only, potential improvement when combined with tracker



Scaling function

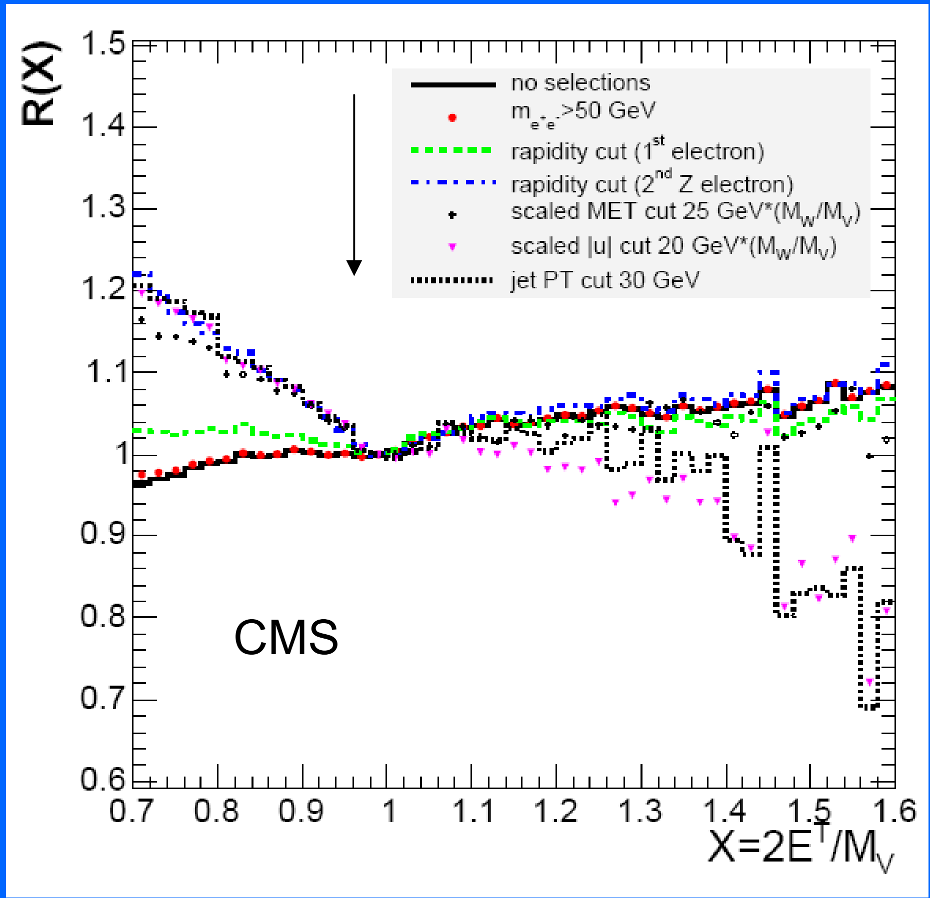
R(X) can be calculated from theory but selection cuts must also be applied.

W-mass measurements require precise understanding of experiment and theory
→Requires >$10 fb^{-1}$

Transformation method reduces this be cancelling many detector and theory effect

Prospects for $1 fb^{-1}$
40MeV stat and 40MeV sys

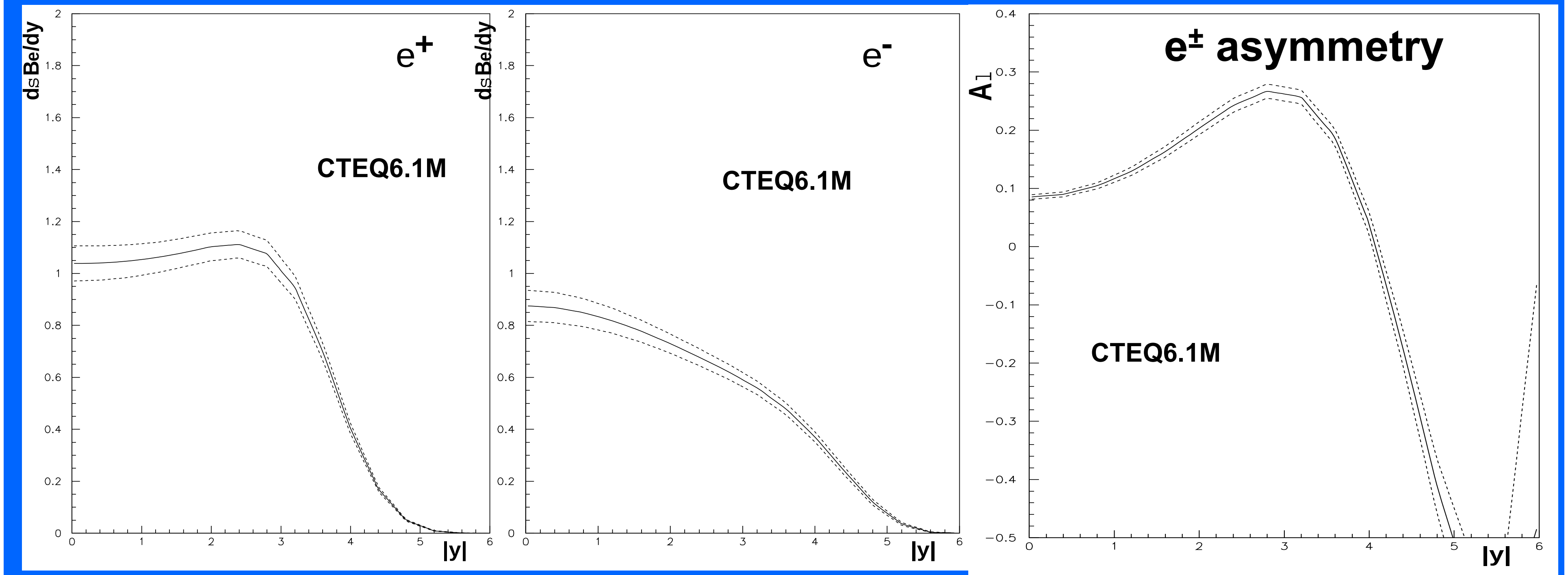
Cuts applied sequentially



$e^{\pm}$ Rapidity Distributions from $W^{\pm}$ decay

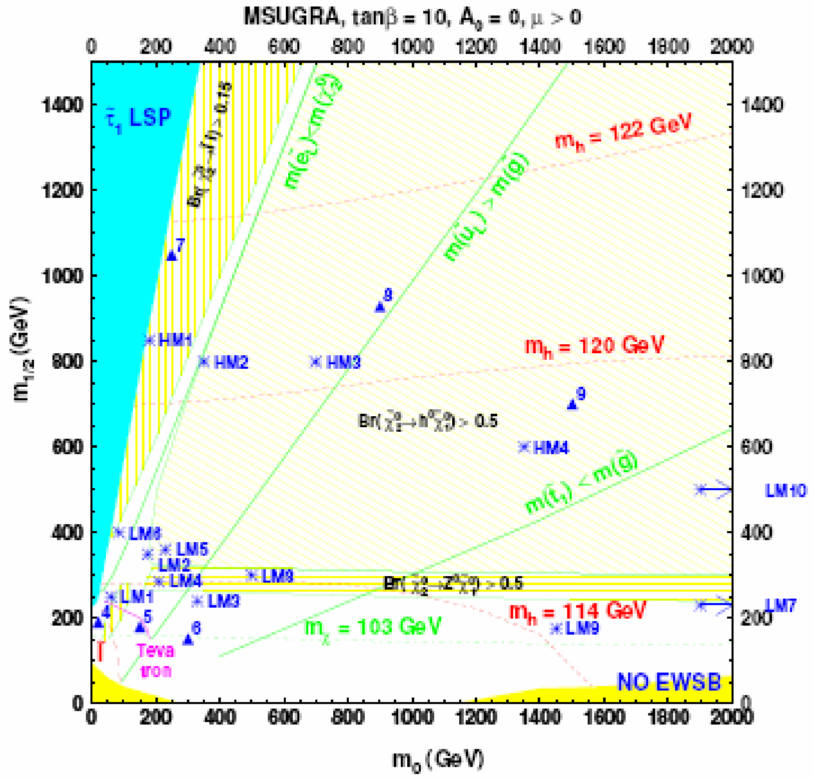
Since W cannot be fully reconstructed: we measure W's decay charged lepton rapidity spectra

Analytic calculations: Error bands are the full PDF Uncertainties; electron p_T >25 GeV

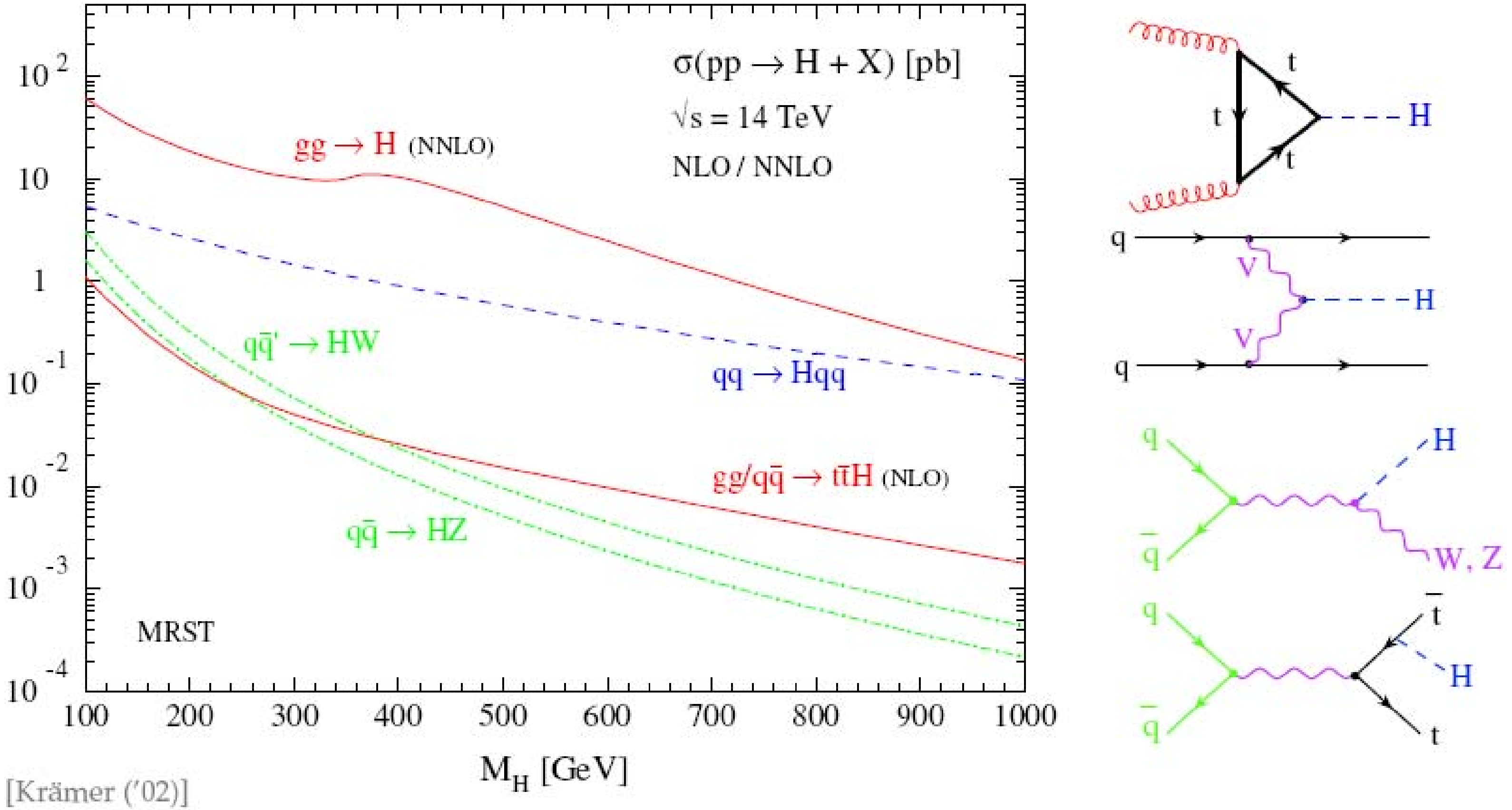


- **On $e^{\pm}$ rapidity distributions:**
  - sensitivity to gluon parameters remains similar to $W^{\pm}$ rapidity distributions
- **On $e^{\pm}$ Asymmetry:**
  - change in sign at large y: V-A theory feature of lepton decay
  - gluon uncertainty cancellation not as perfect as in W Asymmetry
    - in measurable region $|\eta|<2.5$ PDF error ~4%: SM benchmark.

- **Point LM1** :
  - Same as post-WMAP benchmark point B′ and near DAQ TDR point 4.
  - $m(\tilde{g}) \geq m(\tilde{q})$, hence $\tilde{g} \to \tilde{q}q$ is dominant
  - $B(\tilde{\chi}^0_2 \to \tilde{l}_R l) = 11.2\%$, $B(\tilde{\chi}^0_2 \to \tilde{\tau}_1\tau) = 46\%$, $B(\tilde{\chi}^\pm_1 \to \tilde{\nu}_l l) = 36\%$
- **Point LM2** :
  - Almost identical to post-WMAP benchmark point I′.
  - $m(\tilde{g}) \geq m(\tilde{q})$, hence $\tilde{g} \to \tilde{q}q$ is dominant ($\tilde{b}_1 b$ is 25%)
  - $B(\tilde{\chi}^0_2 \to \tilde{\tau}_1\tau) = 96\%$ $B(\tilde{\chi}^\pm_1 \to \tilde{\tau}\nu) = 95\%$
- **Point LM3** :
  - Same as NUHM point γ and near DAQ TDR point 6.
  - $m(\tilde{g}) < m(\tilde{q})$, hence $\tilde{g} \to \tilde{q}q$ is forbidden except $B(\tilde{g} \to \tilde{b}_{1,2}b) = 85\%$
  - $B(\tilde{\chi}^0_2 \to ll\tilde{\chi}^0_1) = 3.3\%$, $B(\tilde{\chi}^0_2 \to \tau\tau\tilde{\chi}^0_1) = 2.2\%$, $B(\tilde{\chi}^\pm_1 \to W^\pm\tilde{\chi}^0_1) = 100\%$
- **Point LM4** :
  - Near NUHM point α in the on-shell Z^0 decay region
  - $m(\tilde{g}) \geq m(\tilde{q})$, hence $\tilde{g} \to \tilde{q}q$ is dominant with $\tilde{g} \to \tilde{b}_1 b = 24\%$
  - $B(\tilde{\chi}^0_2 \to Z^0\tilde{\chi}^0_1) = 97\%$, $B(\tilde{\chi}^\pm_1 \to W^\pm\tilde{\chi}^0_1) = 100\%$
- **Point LM5** :
  - In the h^0 decay region, same as NUHM point β.
  - $m(\tilde{g}) \geq m(\tilde{q})$, hence $\tilde{g} \to \tilde{q}q$ is dominant with $B(\tilde{g} \to \tilde{b}_1 b) = 19.7\%$ and $B(\tilde{g} \to \tilde{t}_1 t) = 23.4\%$
  - $B(\tilde{\chi}^0_2 \to h^0\tilde{\chi}^0_1) = 85\%$, $B(\tilde{\chi}^0_2 \to Z^0\tilde{\chi}^0_1) = 11.5\%$, $B(\tilde{\chi}^\pm_1 \to W^\pm\tilde{\chi}^0_1) = 97\%$
- **Point LM6** :
  - Same as post-WMAP benchmark point C′.
  - $m(\tilde{g}) \geq m(\tilde{q})$, hence $\tilde{g} \to \tilde{q}q$ is dominant
  - $B(\tilde{\chi}^0_2 \to \tilde{l}_L l) = 10.8\%$, $B(\tilde{\chi}^0_2 \to \tilde{l}_R l) = 1.9\%$, $B(\tilde{\chi}^0_2 \to \tilde{\tau}_1\tau) = 14\%$, $B(\tilde{\chi}^\pm_1 \to \tilde{\nu}_l l) = 44\%$
- **Point LM7** :
  - Very heavy squarks, outside reach, but light gluino.
  - $m(\tilde{g}) = 678\ \mathrm{GeV/c^2}$, hence $\tilde{g} \to$ 3-body is dominant
  - $B(\tilde{\chi}^0_2 \to ll\tilde{\chi}^0_1) = 10\%$, $B(\tilde{\chi}^\pm_1 \to \nu l\tilde{\chi}^0_1) = 33\%$
  - EW chargino-neutralino production cross-section is about 73% of total.
- **Point LM8** :
  - Gluino lighter than squarks, except $\tilde{b}_1$ and $\tilde{t}_1$
  - $m(\tilde{g}) = 745\ \mathrm{GeV/c^2}$, $M(\tilde{t}_1) = 548\ \mathrm{GeV/c^2}$, $\tilde{g} \to \tilde{t}_1 t$ is dominant
  - $B(\tilde{g} \to \tilde{t}_1 t) = 81\%$, $B(\tilde{g} \to \tilde{b}_1 b) = 14\%$, $B(\tilde{q}_L \to q\tilde{\chi}^0_2) = 26-27\%$,
  - $B(\tilde{\chi}^0_2 \to Z^0\tilde{\chi}^0_1) = 100\%$, $B(\tilde{\chi}^\pm_1 \to W^\pm\tilde{\chi}^0_1) = 100\%$
- **Point LM9** :
  - Heavy squarks, light gluino. Consistent with EGRET data on diffuse gamma ray spectrum, WMAP results on CDM and mSUGRA [674]. Similar to LM7.
  - $m(\tilde{g}) = 507\ \mathrm{GeV/c^2}$, hence $\tilde{g} \to$ 3-body is dominant
  - $B(\tilde{\chi}^0_2 \to ll\tilde{\chi}^0_1) = 6.5\%$, $B(\tilde{\chi}^\pm_1 \to \nu l\tilde{\chi}^0_1) = 22\%$
- **Point LM10** :
  - Similar to LM7, but heavier gauginos.
  - Very heavy squarks, outside reach, but light gluino.
  - $m(\tilde{g}) = 1295\ \mathrm{GeV/c^2}$, hence $\tilde{g} \to$ 3-body is dominant
  - $B(\tilde{g} \to t\bar{t}\tilde{\chi}^0_4) = 11\%$, $B(\tilde{g} \to tb\tilde{\chi}^\pm_2) = 27\%$

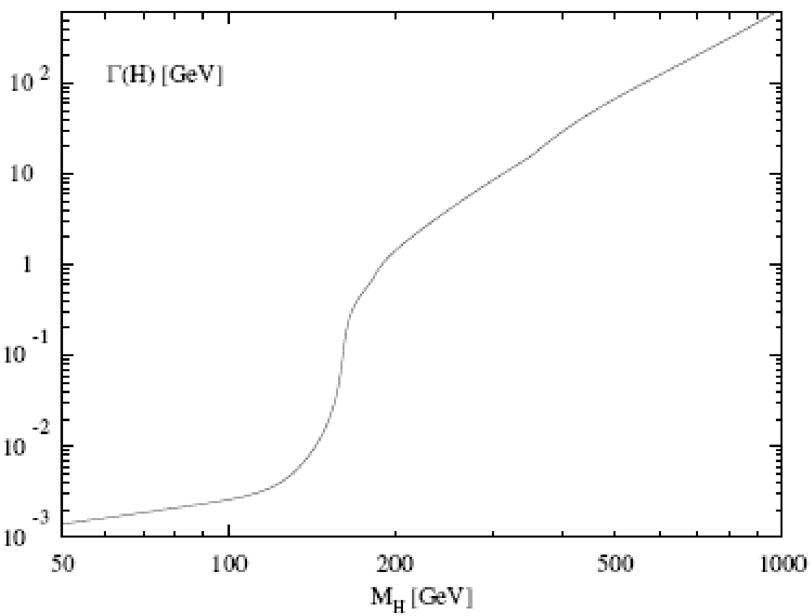


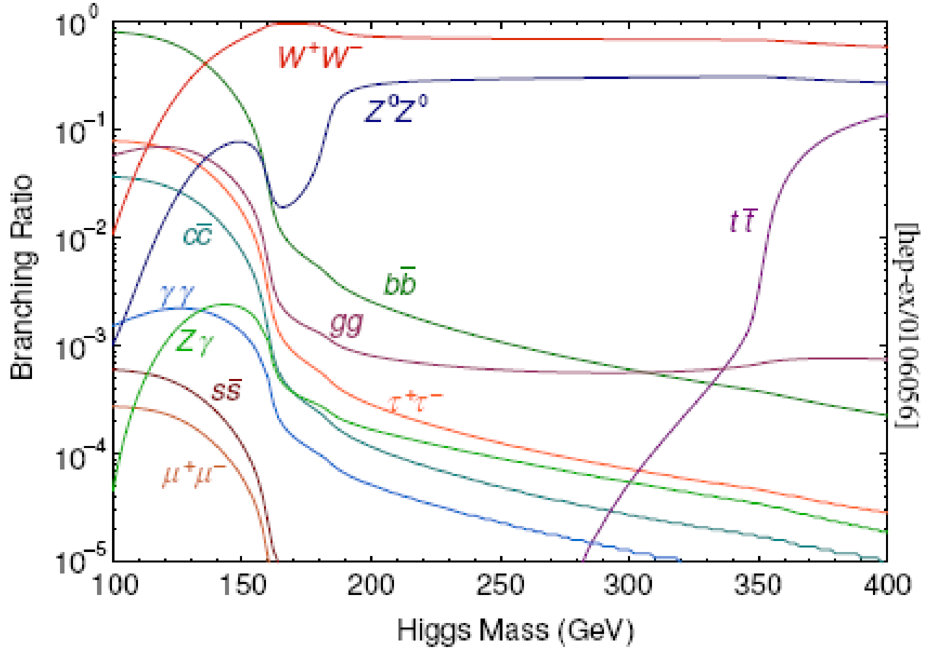
Total SM Higgs cross sections at the LHC



Decay of the SM Higgs

Higgs decay width and branching fractions within the SM





Extract effect of UE from data

- Use inclusive Z-sample, high statistics
- Similar dependence to ZZ sample but small systematic shift