Rencontres de Moriond EW, La Thuile, March 19, 2014

TEVATRON
Top Quark Mass

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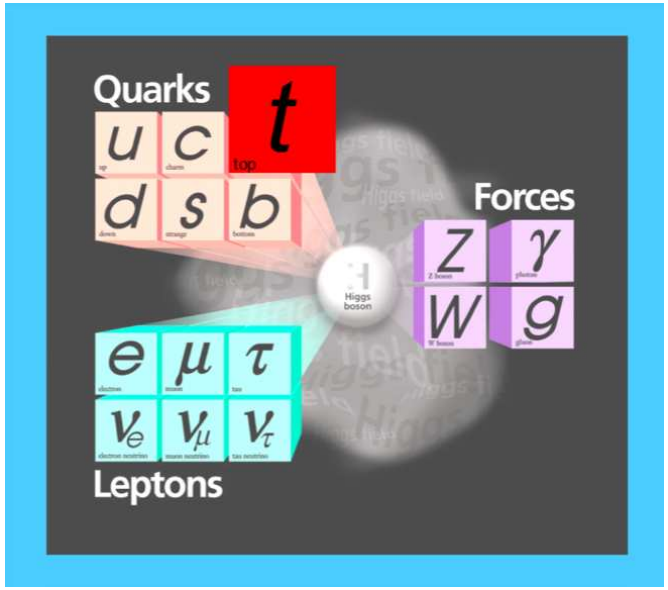
On behalf of the CDF and DØ Collaborations

OUTLINE

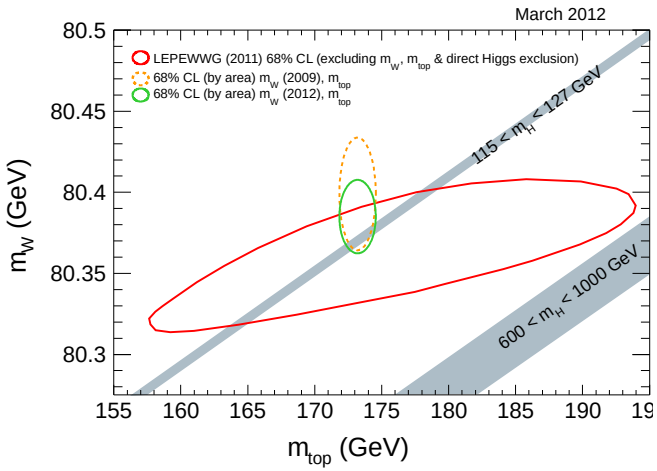
- **The Top Quark**
- **Measurement Strategies.**
- **Recent Results.**
- **M_{top} World Average**
- **Summary and Conclusions.**

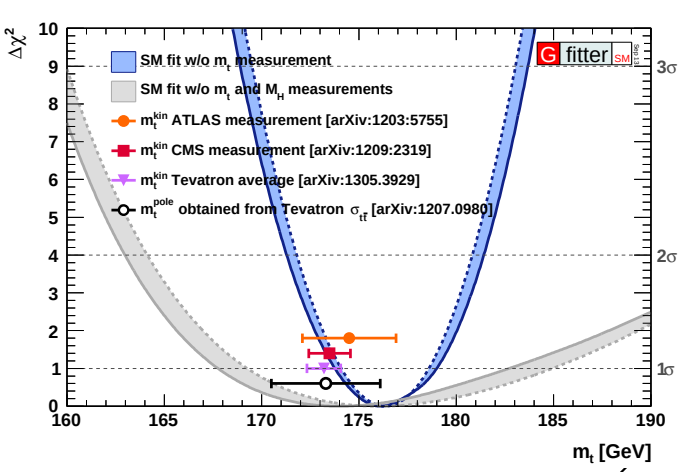
The Top Quark



- **Observed in 1995 at Fermilab....**
  ... not a big surprise (...if we trust the SM...)
- **... but M_{top} striking large!**

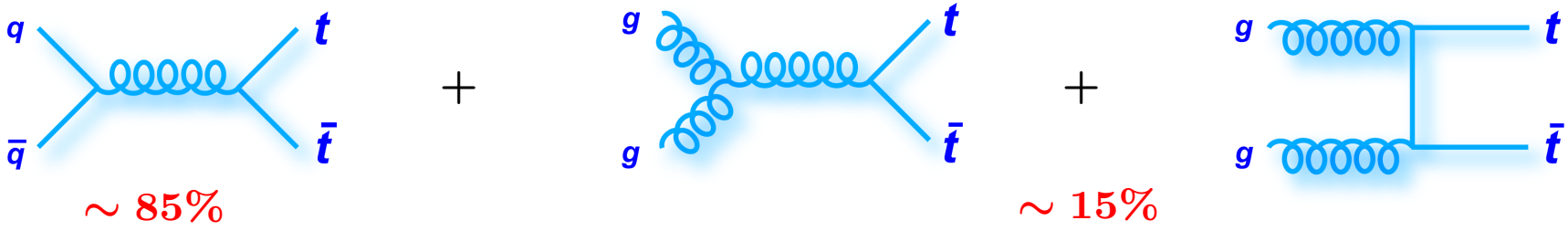
- **Why (keep on) to measure M_{top} ?**
  - **Inside the SM :**
    - **Test SM predictions**
    - **Test SM consistency**
  - **Beyond the SM :**
    - **Constraints on New Physics**
    - **Hints on EWSB?**





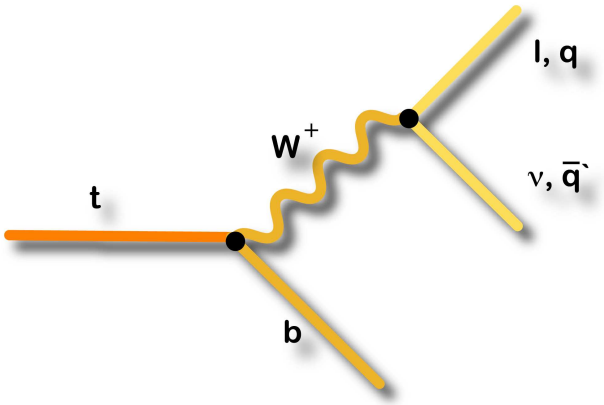
Top Quark Signatures

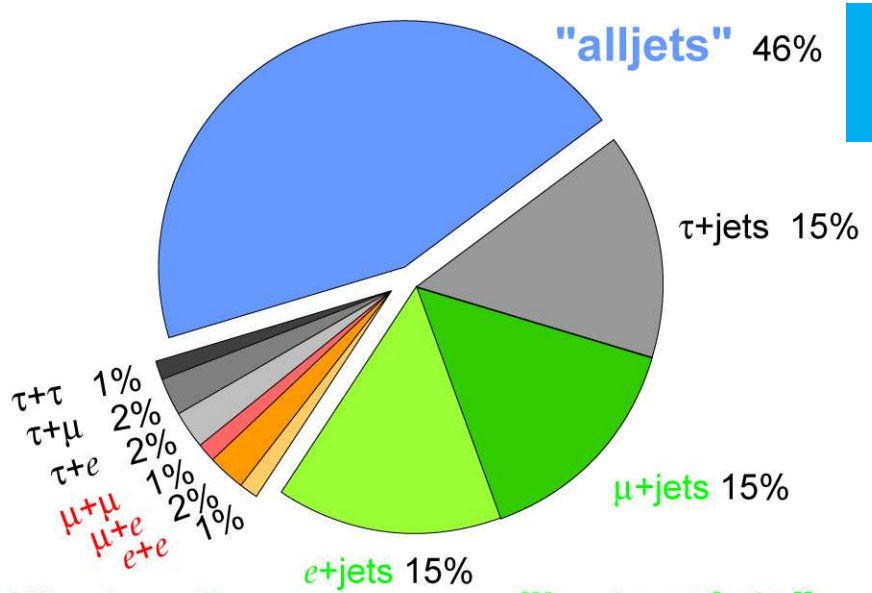
At the Tevatron mainly $t\bar{t}$ production via strong interaction



$\sim 85\%$ $\sim 15\%$

In the SM : $BR(t \to Wb) \simeq 100\%$ $\Rightarrow$ **$t\bar{t}$ final states defined by Ws' decays**





4 q-jets, 2 b-jets

2 high p_T charged leptons, 2 b-jets, $\not\!\!E_T$

1 high p_T charged lepton, 2 q-jets, 2 b-jets, $\not\!\!E_T$

Top Mass Challenges

- $\sigma_{t\bar{t}} / \sigma_{inel} \simeq 10^{-10}$!!!

  - **... Event Selection :**
    - **Triggers**
    - ***b*-tagging algorithms.**
    - **High E_T and central ($|\eta| \leq 2$) Jets.**
    - **Lepton Id (Dilepton, Lepton + jets).**

- **Reconstruction :**
  - **Measure "Jets" and not partons**

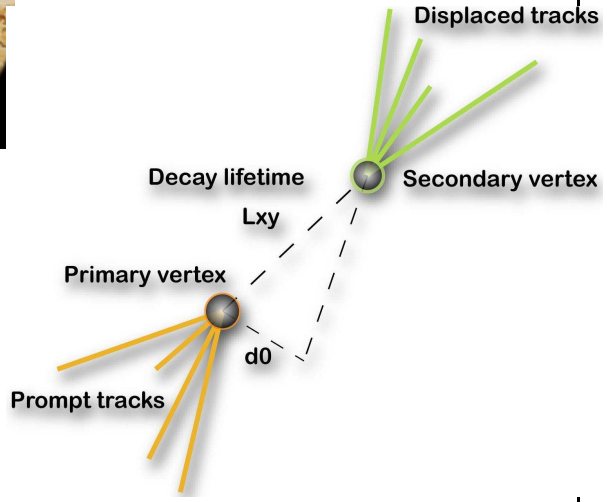
    Need corrections to obtain parton energy
    $\Rightarrow$ **J**et **E**nergy **S**cale. $\sigma_{\rm JES}/{\rm JES} \approx 2\%$ to 6%
    $\Rightarrow$ Important contribution to $\sigma_{\rm M_{top}}(syst)$

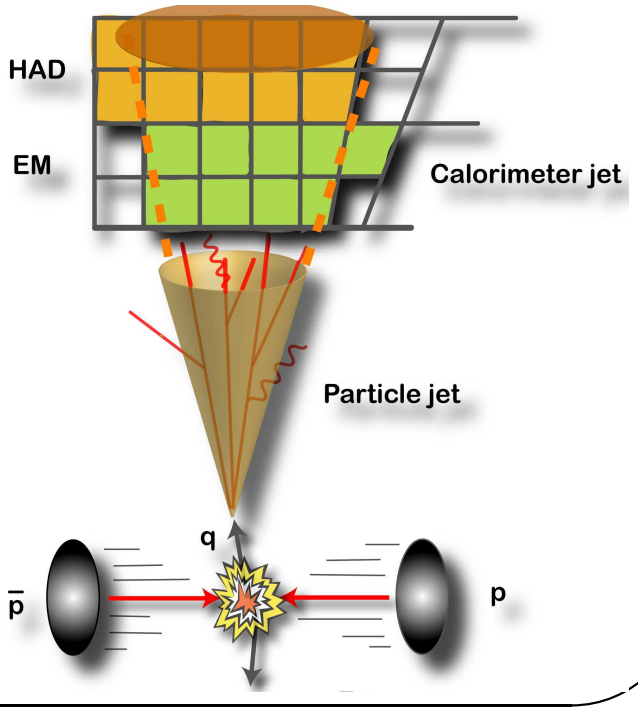
  - **Jets-to-partons assignments**

    Which jet comes from which particle?
    Combinatoric problem!

  - **Undetected ν's (Dilepton, Lepton + jets).**

    Need assumptions. Multiple solutions.



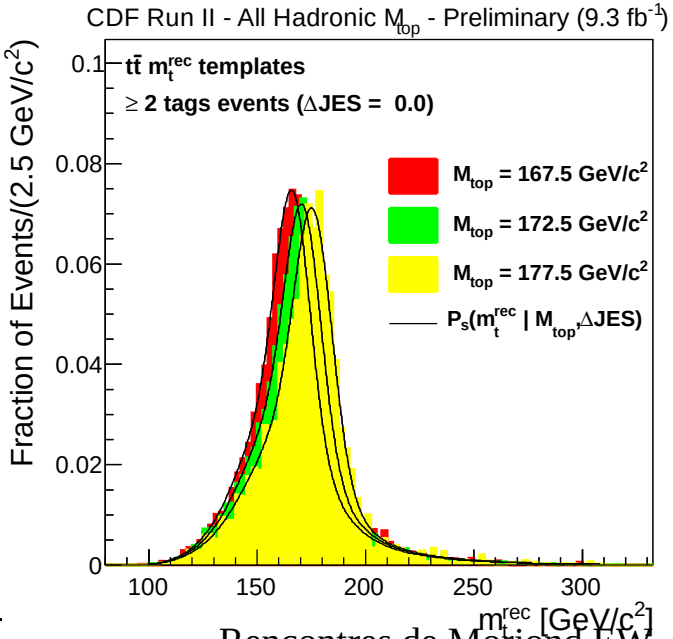


Measurement Strategies

- **Matrix Element (ME)**
  - Define the probability, P_{ev}, that the *observed* kinematics, $\vec{y}$, arise from possible signal or bkg kinematics $\vec{x}$ at parton level :
    - $d\sigma(\vec{x})$ LO differential x-section of a final state $\vec{x}$ at parton level. Depending on $\mathrm{M_{top}}$ for $t\bar{t}$ events, but not for bkg.
    - $\mathcal{W}(\vec{y}, \vec{x})$ "Transfer function", i.e. probability to measure the observed set of variables $\vec{y}$, given $\vec{x}$ at parton level. Depends on JES.
    - $f_{t\bar{t}}$ Fraction of signal events expected in the data.
  - Maximize $\mathcal{L}_{sample} \propto \prod_{events} P_{ev}(\vec{y}, f_{t\bar{t}}, \mathrm{M_{top}})$ evaluated for observed data

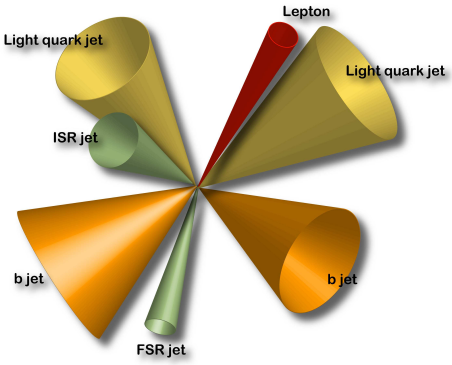
- **Template Method**
  - Consider a set of observables, $\vec{x}$, sensitive to $\mathrm{M_{top}}$. Evaluate and plot the set for each event
    $\Rightarrow$ "Templates"
  - Maximize a likelihood where *observed* distributions are compared to expectations for different $\mathrm{M_{top}}$ and signal fractions, $f_{t\bar{t}}$.

$$\mathcal{L}_{\mathrm{sample}} \propto \prod_{events} \prod_{\vec{x}} \mathcal{L}_{\mathrm{shape}}(x_i | f_{t\bar{t}}, \mathrm{M_{top}})$$



Measurement Channels

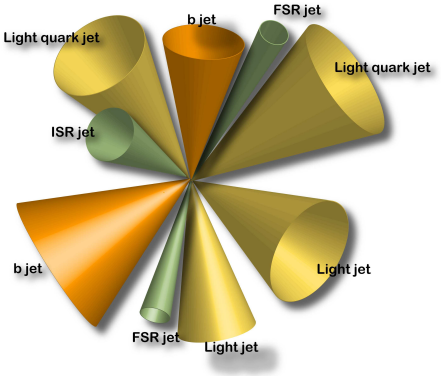
Lepton + Jets



Reasonable Bkg,
Good Statistics....
The Golden Channel!

- Jets-to-Partons assignment ambiguity
- Well reconstructed kinematics (but p_z^ν ambiguity)

All-Jets

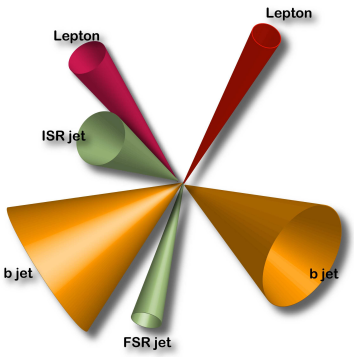


Huge QCD Bkg...
Large Statistics
Challenging!

- Need "fine tuned" selections to obtain good S/B
- Large Jets-to-Partons assignment ambiguity
- Fully reconstructed kinematics

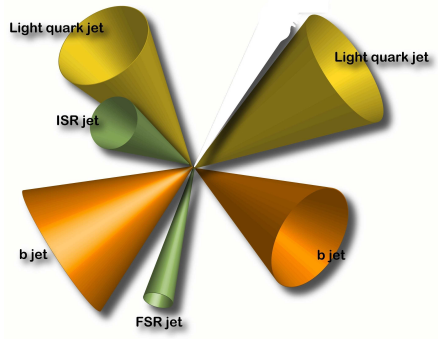
Dilepton

The cleanest sample...
The smallest statistics



- Small combinatoric problem
- Underconstrained kinematics (2 undetected ν's)

Missing E_T + Jets

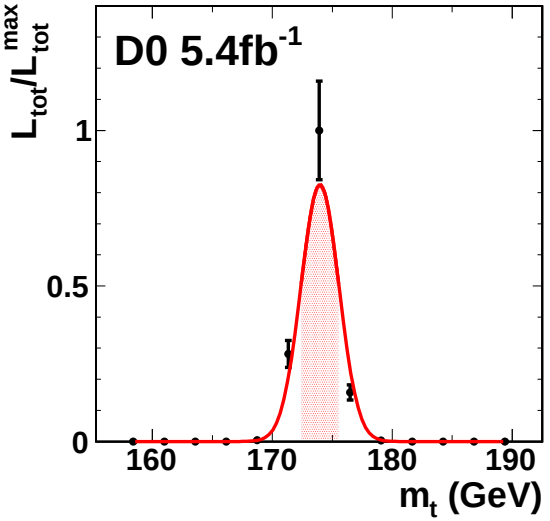


- Selection defined to be complementary to other channels.
- Mostly L + Jets with undetected lepton

Dilepton

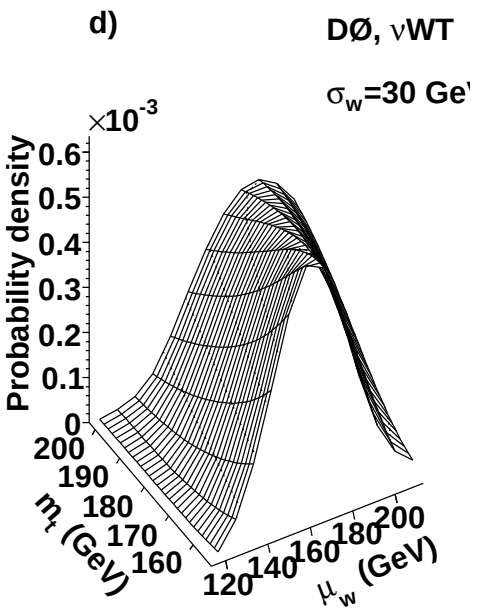
- **DØ, Matrix Element, $5.4\,\mathrm{fb}^{-1}$**
  - Phys. Rev. Lett. 107, 082004 (2011).
  - ee, $e\mu$, $\mu\mu$ channels

$$\mathrm{M_{top}} = 174.0 \pm 1.8\,(stat) \pm 2.4\,(syst)\,\mathrm{GeV}$$



- **DØ, Template by NWA, $4.3 + 1.0\,\mathrm{fb}^{-1}$**
  - Phys. Rev D86, 051103(R) (2012)
  - Neutrino Weighting Algorithm : templates based on an event weight for possible solutions of underconstrained kinematics.
  - ee, $e\mu$, $\mu\mu$ channels, selection similar to ME analysis.
  - JES calibration from Lepton + Jets analysis is used.
  - Combined with NWA + Matrix Weighting @ $1\,\mathrm{fb}^{-1}$

$$\mathrm{M_{top}} = 174.0 \pm 2.4\,(stat) \pm 1.4\,(syst)\,\mathrm{GeV}$$



- **Combination :**

$$\mathrm{M_{top}} = 173.9 \pm 1.9\,(stat) \pm 1.4\,(syst)\,\mathrm{GeV}$$

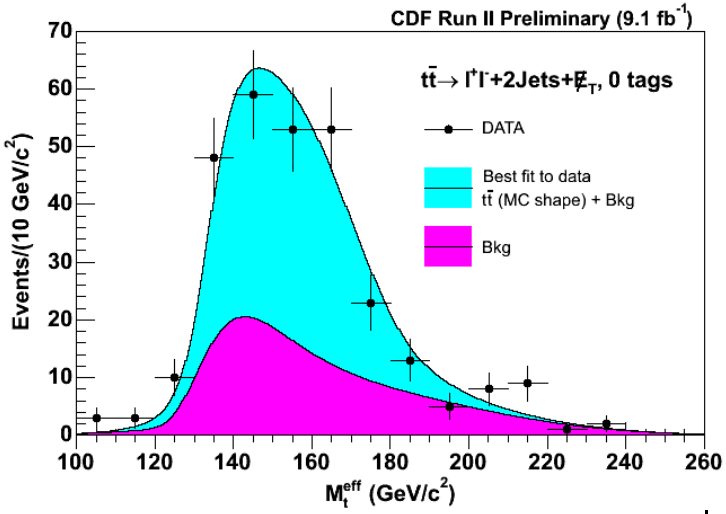
$$\sigma_{\mathrm{M_{top}}}/\mathrm{M_{top}} \simeq 1.4\%$$

Dilepton

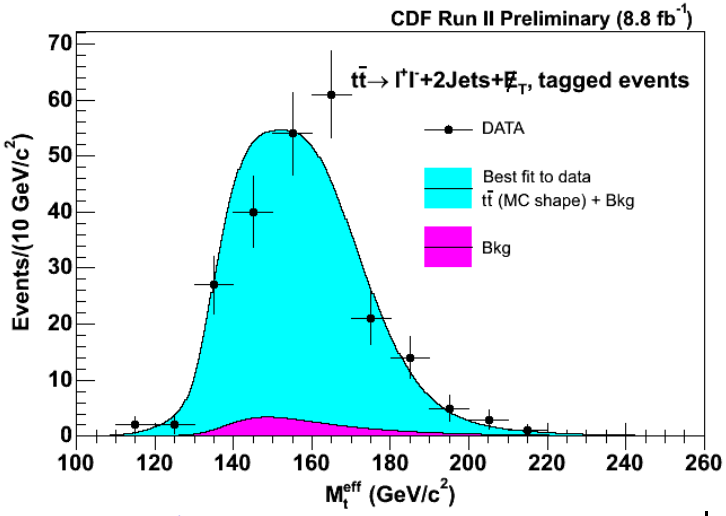
CDF, Templates, $9.1\,\mathrm{fb}^{-1}$

- **New Preliminary result with full CDF dataset (January 2014, CDF conference note 11072)**
- **"Hybrid" variable method to reduce JES uncertainty:**
  - **Templates by** $M_t^{eff} = w \cdot M_t^{reco} + (1-w) \cdot M_t^{alt}$
  - M_t^{reco} **sensitive to true** $\mathrm{M_{top}}$**. Defined by NWA.**
  - M_t^{alt} **less sensitive to** $\mathrm{M_{top}}$**, but not based on jet energies.**
  - $w = 0.7$**:**
    defined to minimize expected (stat + JES) uncertainty
- **Two independent samples: 0-tag,** $\geq$ **1-tag**

$$\mathrm{M_{top}} = 170.80 \pm 1.83\,(stat) \pm 2.69\,(syst)\,\mathrm{GeV}$$
$$\sigma_{\mathrm{M_{top}}}/\mathrm{M_{top}} \simeq 1.9\%$$



0-tag fitted templates

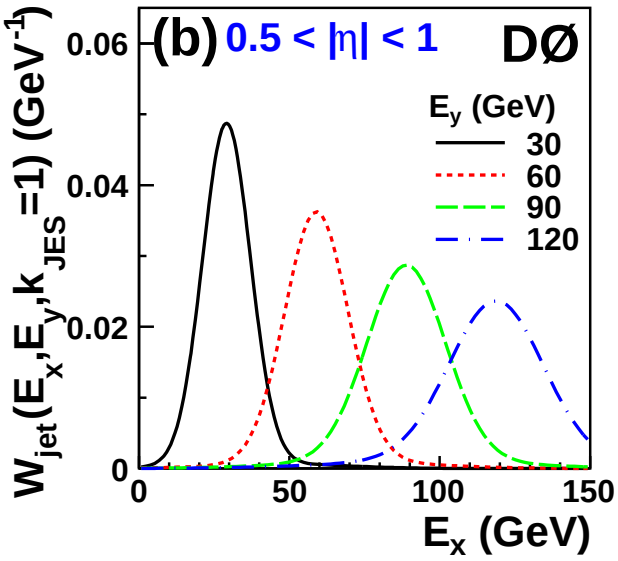


$\geq$ **1**-tag fitted templates

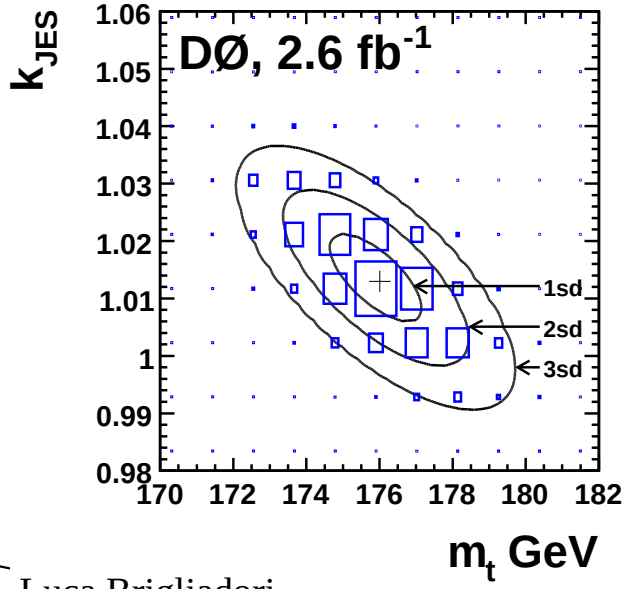
Lepton + Jets

- **DØ, Matrix Element, $2.6 + 1.0\,\mathrm{fb}^{-1}$**

  - **Phys. Rev. D84 (2011) 032004.**
  - **Events with 1 high p_T $e\,/\,\mu$, $\equiv$ 4 Jets, large $\not\!\!E_T$, $\geq$ 1 b-tag**
  - **For each event evaluate ME-based probability as a weighted sum over possible parton-jet combinations**
  - **Dependence on JES given by Transfer Functions $\mathcal{W}(\vec{y},\,\vec{x})$**
  - **Simultaneous JES calibration by jets assigned to W boson.**



Jet E Transfer Functions



$$\mathrm{M_{top}} = 176.01 \pm 1.01\,(stat) \pm 1.29\,(syst)\,\mathrm{GeV}$$

Combined with $1\,\mathrm{fb}^{-1}$ $\Rightarrow$ Best DØ measurement

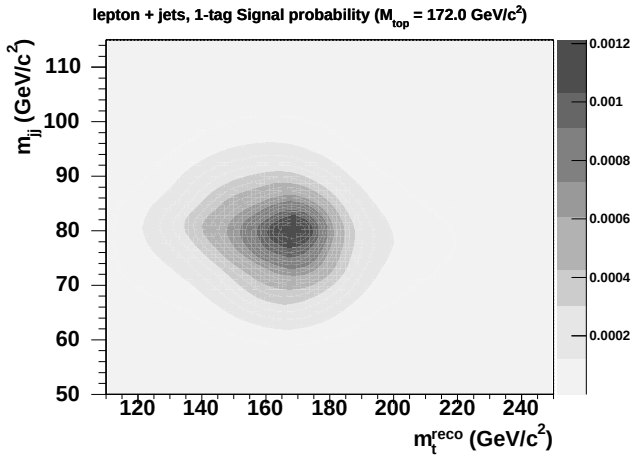
$$\mathrm{M_{top}} = 174.94 \pm 0.83\,(stat) \pm 1.24\,(syst)\,\mathrm{GeV}$$
$$\sigma_{\mathrm{M_{top}}}/\mathrm{M_{top}} \simeq 0.9\%$$

Lepton + Jets

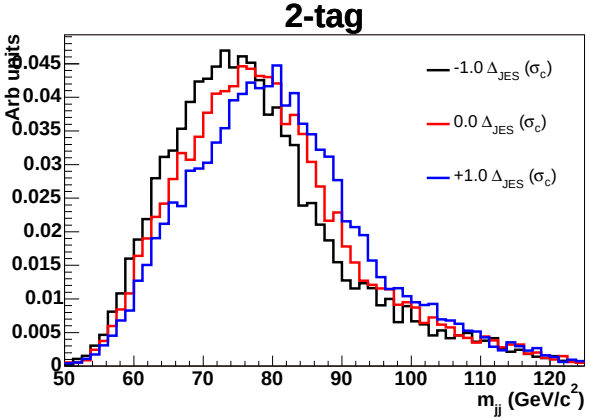
- **CDF, Templates, $8.7\,\mathrm{fb}^{-1}$**
  - **Phys. Rev. Lett. 109 (2012) 152003.**
  - **3D templates : m_t^{reco} *vs* $m_t^{reco(2)}$ *vs* m_{jj}**
  - **m_{jj} used for *in situ* JES calibration**

$$\mathrm{M_{top}} = 172.85 \pm 0.71\,(stat) \pm 0.85\,(syst)\,\mathrm{GeV}$$
$$\sigma_{\mathrm{M_{top}}}/\mathrm{M_{top}} \simeq 0.6\%$$

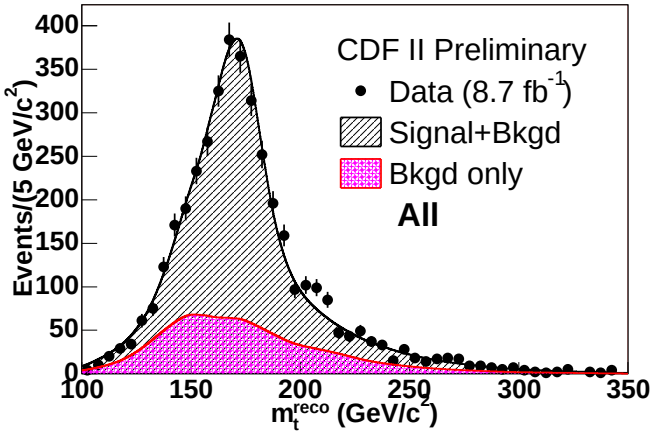
Best single measurement from Tevatron

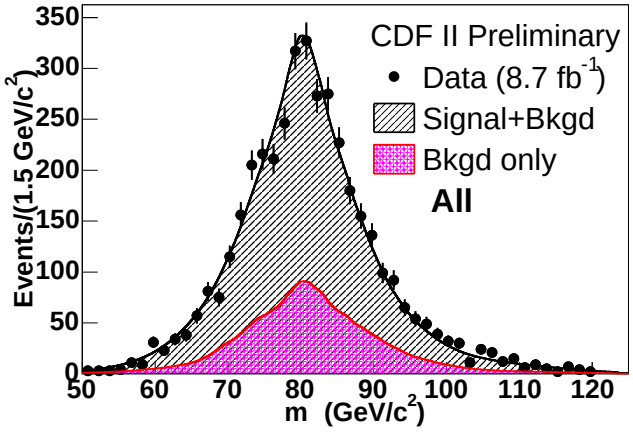


m_{jj} *vs* m_t^{reco}



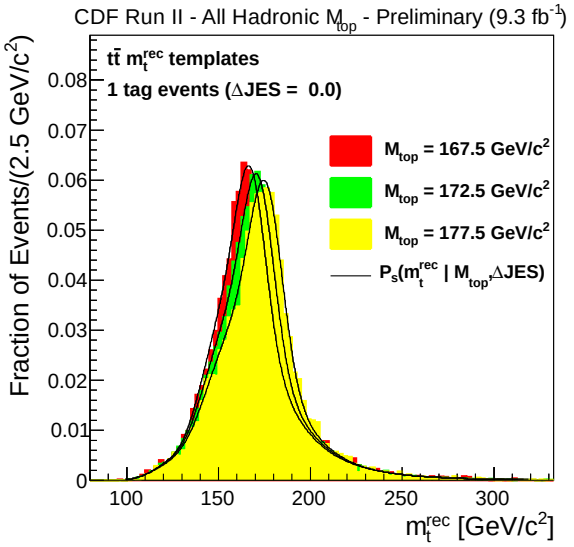
m_{jj} **dependence on JES**

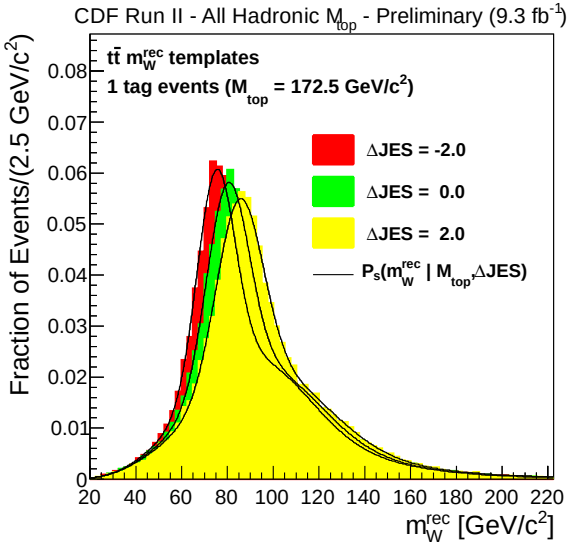


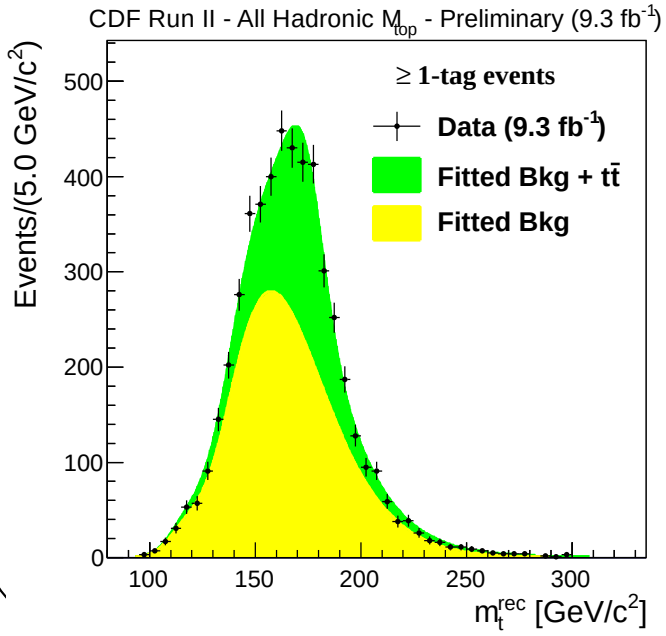


All-Hadronic

- **CDF, Templates, $9.3\,\mathrm{fb}^{-1}$**
  - **New Preliminary result with full CDF dataset (February 2014, CDF conference note 11084)**
  - **Tuned event selection based on Neural Net, *b*-tag**
  - **Data driven bkg modeling**
  - **S/B about $1/1$ for $\geq$ 2-tag events.**
  - **In each event reconstruct (χ^2 minimization) :**
    - **a "top mass", m_t^{rec}**
    - **a "W mass", m_W^{rec} $\Rightarrow$ JES calibration**







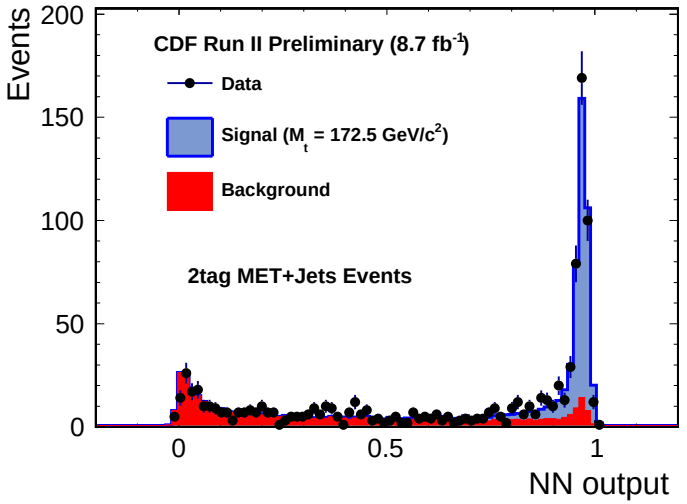
$$\mathrm{M_{top}} = 175.07 \pm 1.19\,(stat) \pm 1.56\,(syst)\,\mathrm{GeV}$$

$$\sigma_{\mathrm{M_{top}}}/\mathrm{M_{top}} \simeq 1.1\%$$

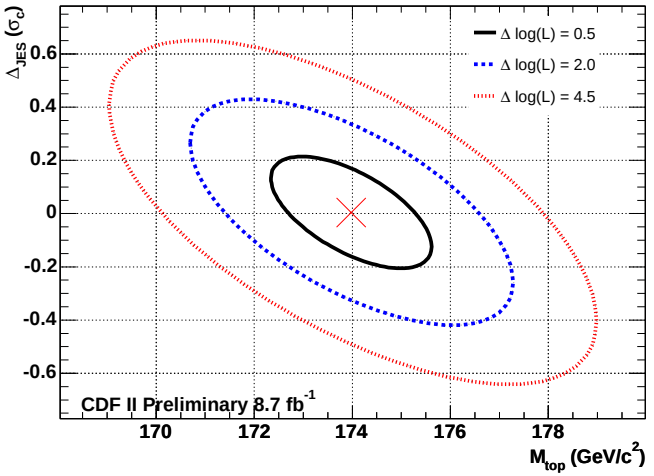
Missing E_T + Jets

- **CDF, Templates, $8.7\,\mathrm{fb}^{-1}$**
  - **Phys. Rev D88 (2013) 011101**
  - **Require large $\not\!\!E_T$, no tight lepton**

    $\Rightarrow$ **independent of All-Had, L+jets, Dilepton**
  - **Exploiting NN selection and bkg modeling similar to All-Had analysis**
  - **$\not\!\!E_T$ treated as due to $W \to \ell\nu$ with "lost" charged lepton in event reconstruction**
  - **Same technique used in CDF L+jets :**
    - **3D templates using m_t^{reco}, $m_t^{reco(2)}$, m_{jj}**
    - **m_{jj} used for *in situ* JES calibration**



Neural Net Output



$$\mathrm{M_{top}} = 173.93 \pm 1.26\,(stat) \pm 1.36\,(syst)\,\mathrm{GeV}$$
$$\sigma_{\mathrm{M_{top}}}/\mathrm{M_{top}} \simeq 1.1\%$$

M_{top} Systematic Uncertainties

CDF Run II Preliminary (9.1 fb^{-1})

M_{top} Measurement in the $t\bar{t}$ Dilepton Final State	
Source	Uncertainty (GeV/c^2)
Jet energy scale	2.42
NLO effects	0.64
Monte Carlo generators	0.49
Lepton energy scale	0.36
b-jet energy scale	0.34
Initial and final state radiation	0.33
Background modeling	0.33
Luminosity profile (pileup)	0.30
Color reconnection	0.24
gg fraction	0.24
Parton distribution functions	0.21
MC statistics	0.19
b-tagging	0.05
Total systematic	2.69
Statistical	1.83
Total	**3.25**

⇐ **example from CDF Dileptons**

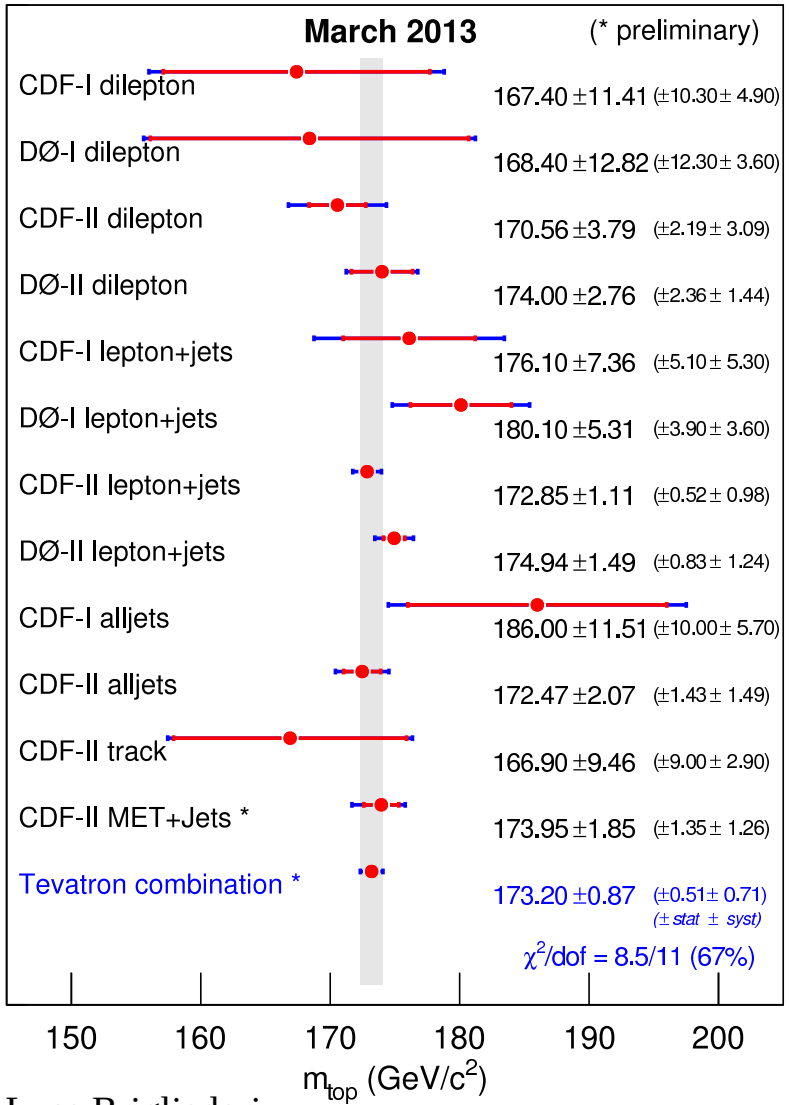
- **Precision on the Top Mass measurements now limited by systematic uncertainties in all channels.**
- **JES uncertainty greatly reduced especially by *in situ* calibration techniques**
  ⇒ **partially statistical**
- **CDF and DØ Collaborations performed a joint effort in the past years in order :**
  - **to define a common way to evaluate systematics**
  - **to avoid possible "double counting" of some effect**
  - **to evaluate correlations among different measurements**
  - **to study possible neglected sources of uncertainties**

Tevatron Top Mass

CDF + DØ, March 2013 (arXiv:1305.3939)

$$M_{top} = 173.20 \pm 0.51(stat) \pm 0.71(syst)\ \text{GeV}$$

Mass of the Top Quark



Individual channels

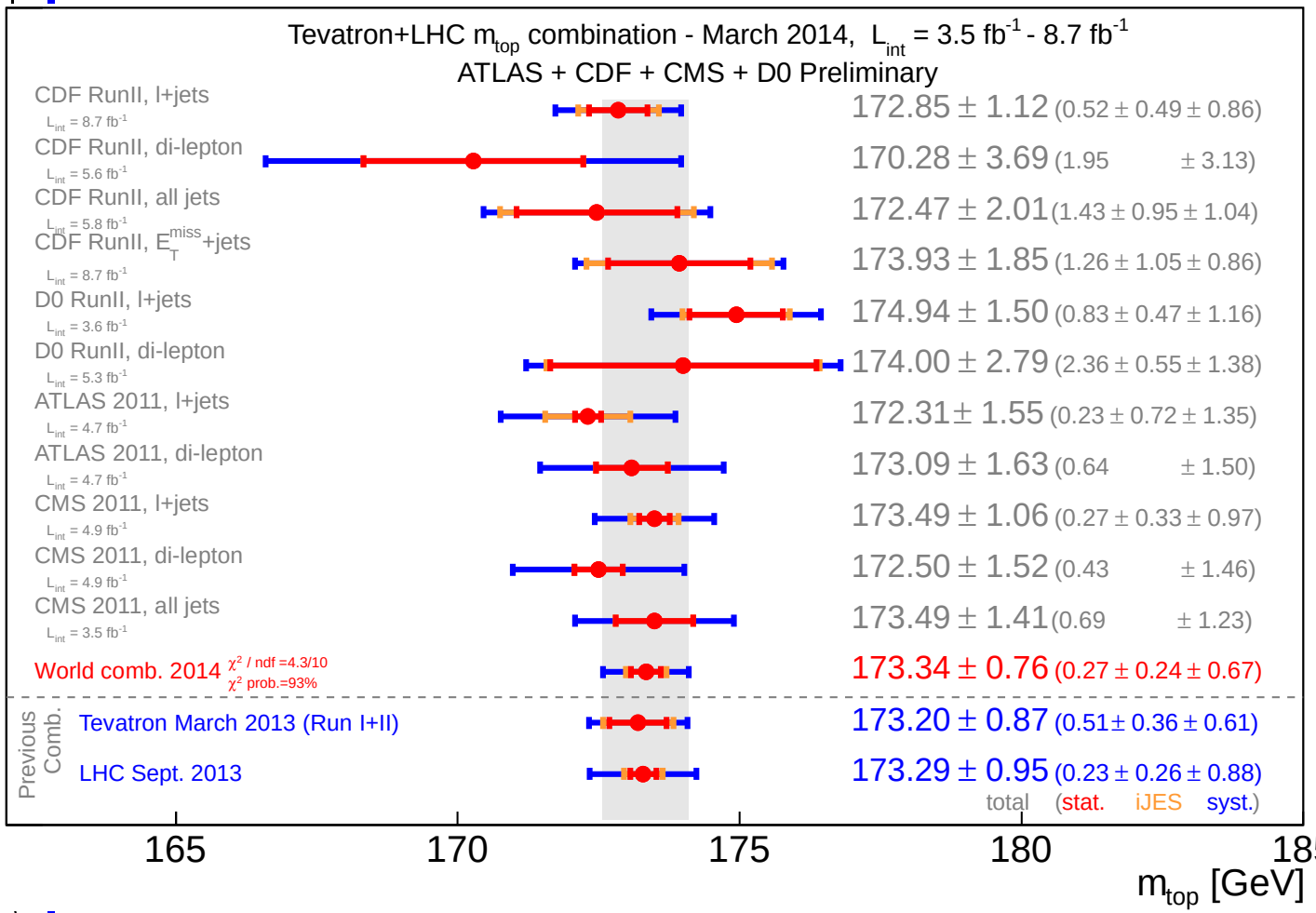
Dilepton	$M_{top} = 170.0 \pm 2.1$ GeV
Lepton + Jets	$M_{top} = 173.2 \pm 0.9$ GeV
All-Hadronic	$M_{top} = 172.7 \pm 1.9$ GeV
$\not\!\!E_T$ + Jets	$M_{top} = 173.8 \pm 1.8$ GeV

- **Best results of each experiment in each channel from Run I and Run II combined.**
- **Recent updates from CDF not included yet**
- **All correlations taken into account.**
- **Good agreement among results from individual channels**
- **M_{top} known at 0.50% (March '13).**
- **Precision now limited by systematic uncertainties in all channels.**

M_{top} WORLD AVERAGE

The ATLAS, CDF, CMS and DØ Collaborations just approved the
very first Tevatron + LHC M_{top} combination

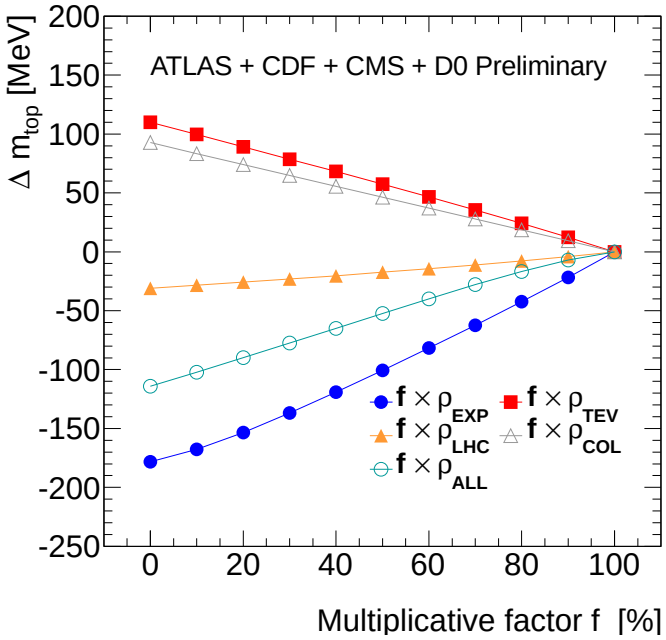
$$M_{top} = 173.34 \pm 0.76\ \text{GeV}$$

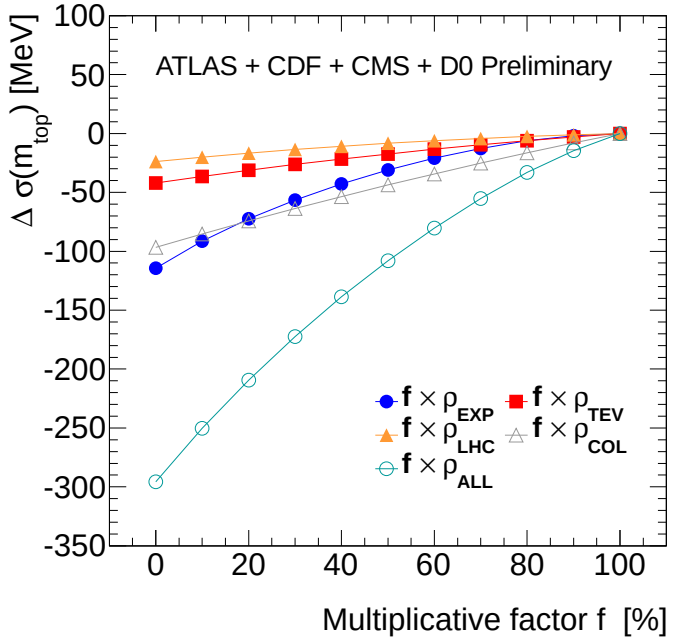


- arXiv 1403.4427 [hep-ex]
- **Tevatron : Run II data (up to 8.7 fb^{-1})**
- **LHC : 2011 data (up to 4.9 fb^{-1})**
- **Best single measurement in each channel from each experiment**
- **13% improvement w.r.t. most precise single Collider combination**
- **28% improvement w.r.t. most precise single input**

M_{top} WORLD AVERAGE

	ρ_{EXP}				ρ_{LHC}	ρ_{TEV}	ρ_{COL}	
	ρ_{CDF}	ρ_{D0}	ρ_{ATL}	ρ_{CMS}			$\rho_{ATL-TEV}$	$\rho_{CMS-TEV}$
Stat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
iJES	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
stdJES	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
flavourJES	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
bJES	1.0	1.0	1.0	1.0	0.5	1.0	1.0	0.5
MC	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Rad	1.0	1.0	1.0	1.0	1.0	1.0	0.5	0.5
CR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
PDF	1.0	1.0	1.0	1.0	1.0	1.0	0.5	0.5
DetMod	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
b-tag	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
LepPt	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
BGMC†	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
BGData	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Meth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MHI	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0

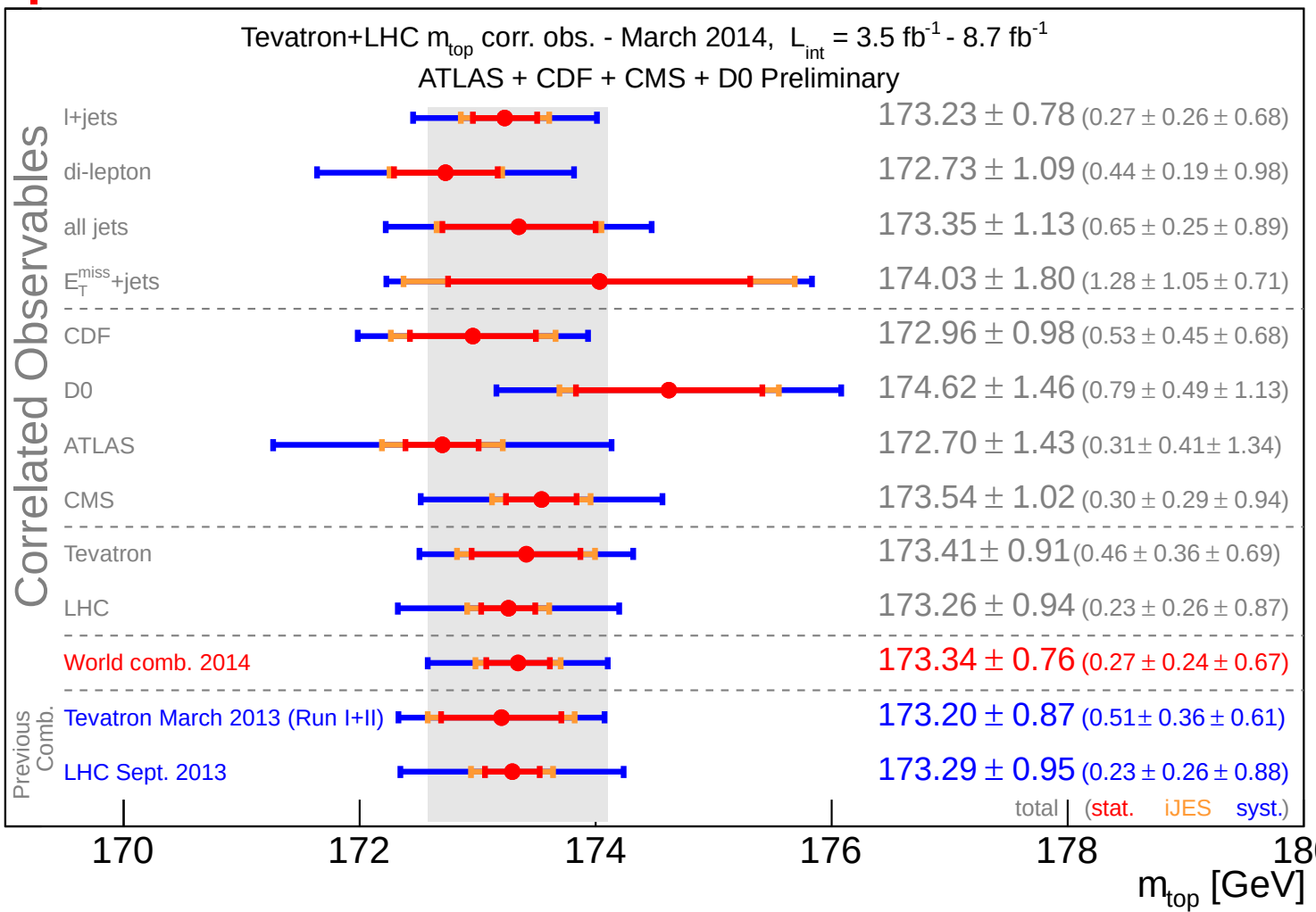




- **First combination between the two Colliders**
- **Big effort performed in order to :**
  - **classify uncertainties**
  - **define correlations**
- **Various correlation scenarios have been checked**

M_{top} WORLD AVERAGE

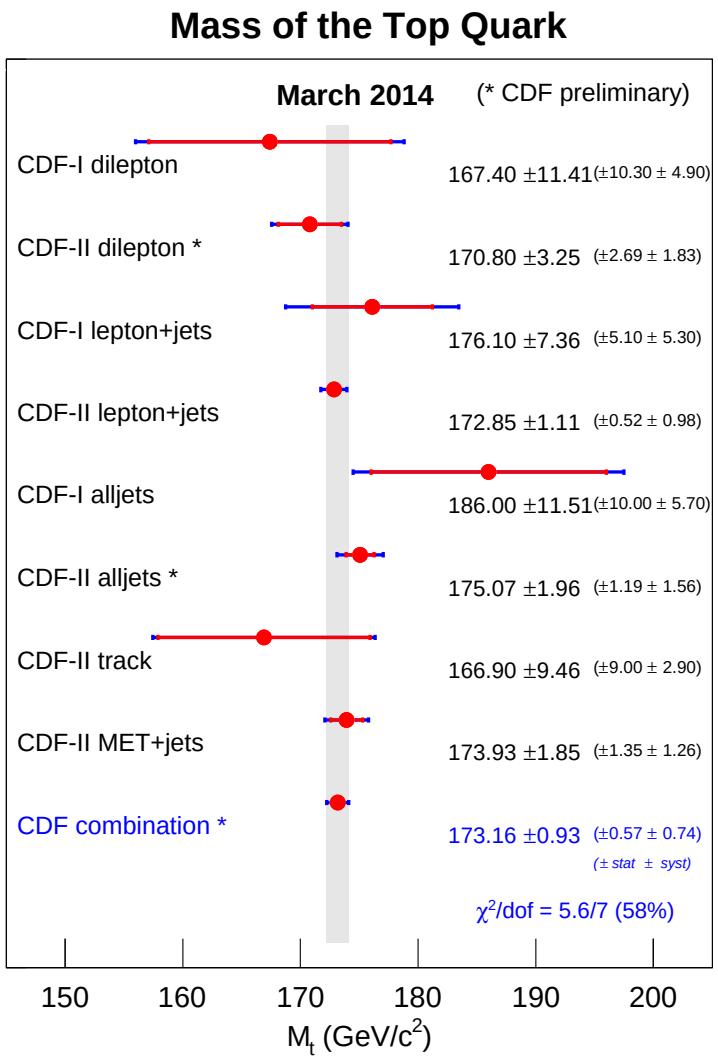
- **Combine channels / experiments / colliders simultaneosly but separately (i.e. correlated but different m_{top} fit parameters)**



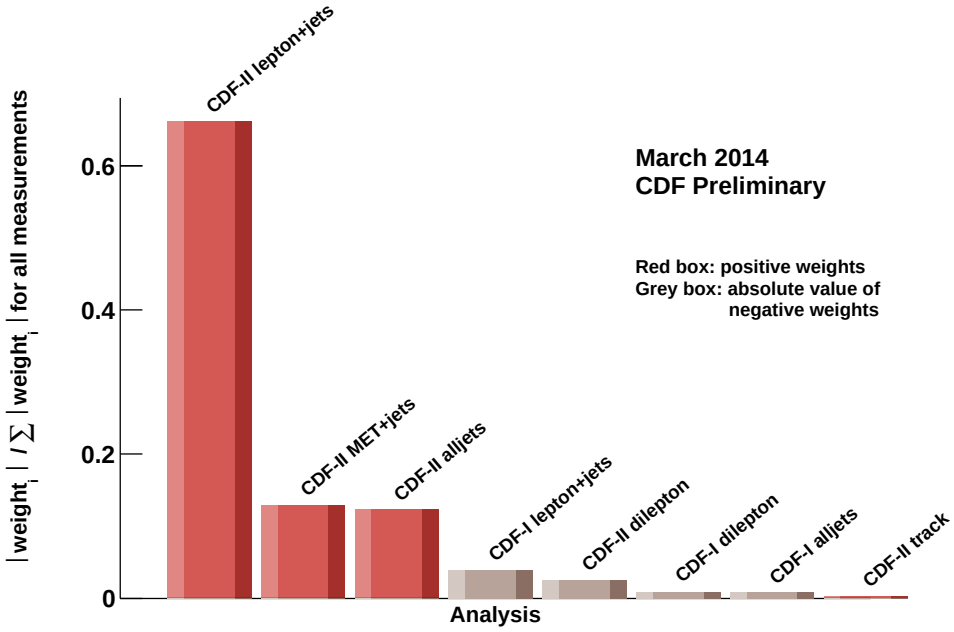
- **Very good agreement among all fitted values**
- **ATLAS-CONF-2014-008**
  CDF note 11071
  CMS PAS TOP-13-014
  DØ note 6416

NEW CDF Top Mass

- **New CDF update :**
  - The CDF collaboration just approved a new combination of measurements.
  - All channels now updated with full dataset. CDF public note 11080



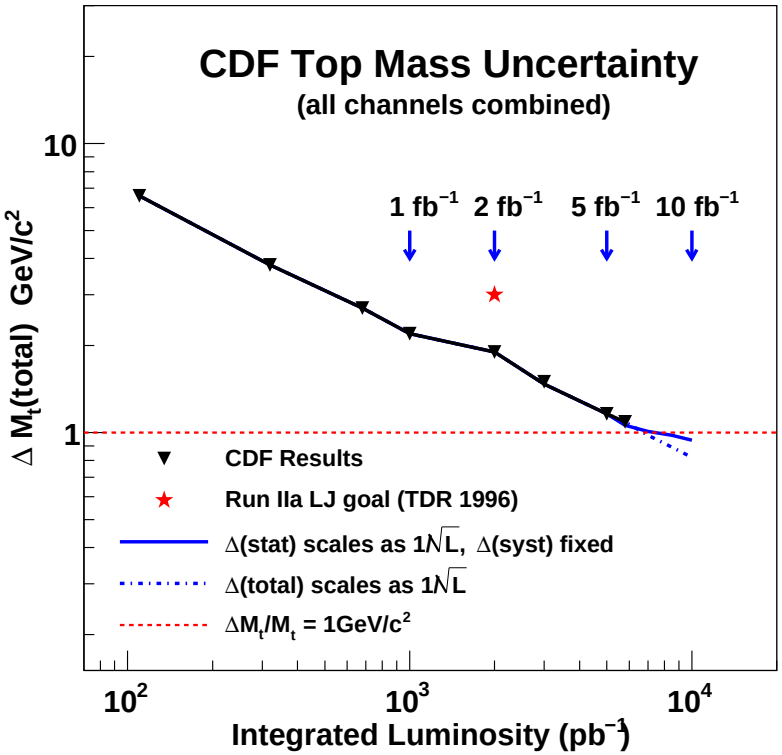
$$M_{top} = 173.16 \pm 0.57(stat) \pm 0.74(syst)\ \text{GeV}$$
$$= 173.16 \pm 0.93\ \text{GeV}$$



- **Last word on M_{top} from CDF**

Conclusions

- **The Fermilab TEVATRON was shut down in September 2011**
  $\sim 10\,\mathrm{fb}^{-1}$ of data collected by experiments during Run II.
- **The Collaborations are finalizing measurements of the Top Quark Mass using full datasets**
- **A selection of more recent ones has been presented in this talk. Full details in**
  - **www-cdf.fnal.gov/physics/new/top/public_mass.html**
  - **www-d0.fnal.gov/Run2Physics/top/**
- **Excellent results from all decay channels. Uncertainty now everywhere dominated by systematics.**
- **Results from individual experiments have precisions by far beyond Run IIa goal.**
- **Tevatron competitive with LHC.**
- **It's time for $\mathrm{M_{top}}$ World Average**



Now : $\sigma_{\mathrm{M_{top}}} \simeq 0.93\,\mathrm{GeV}$

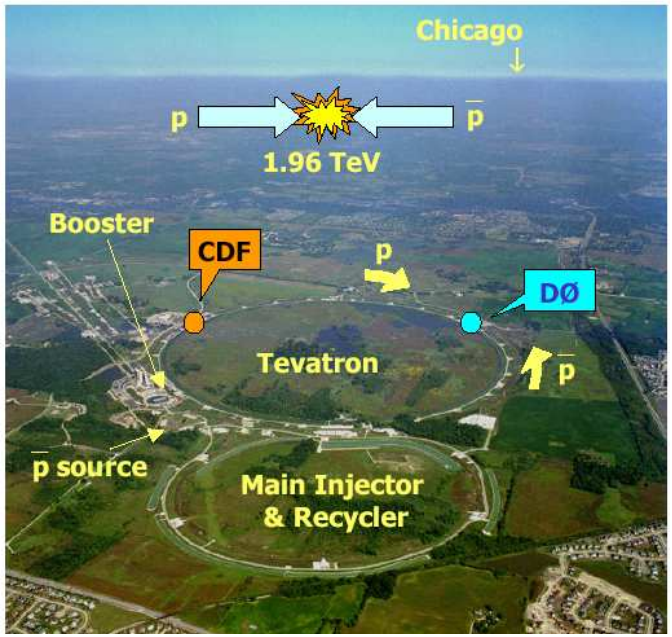
LHC + TEVATRON, March 2014

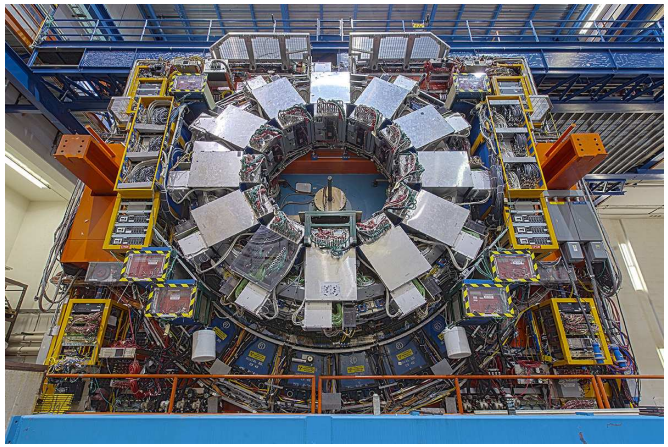
$$\mathrm{M_{top}} = 173.34 \pm 0.76\,\mathrm{GeV}$$

$$\sigma_{\mathrm{M_{top}}}/\mathrm{M_{top}} \simeq 0.44\%$$

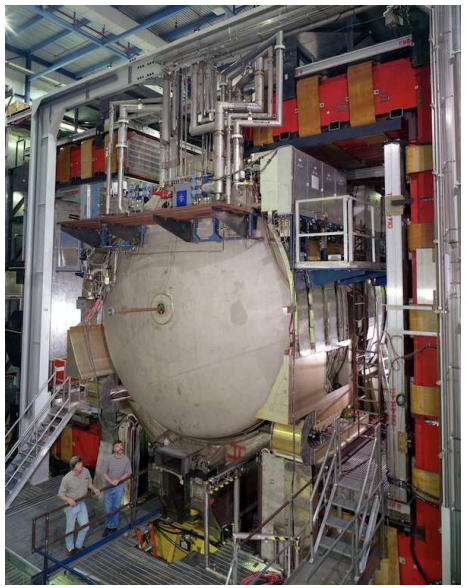
Backup

The Tevatron Experiments

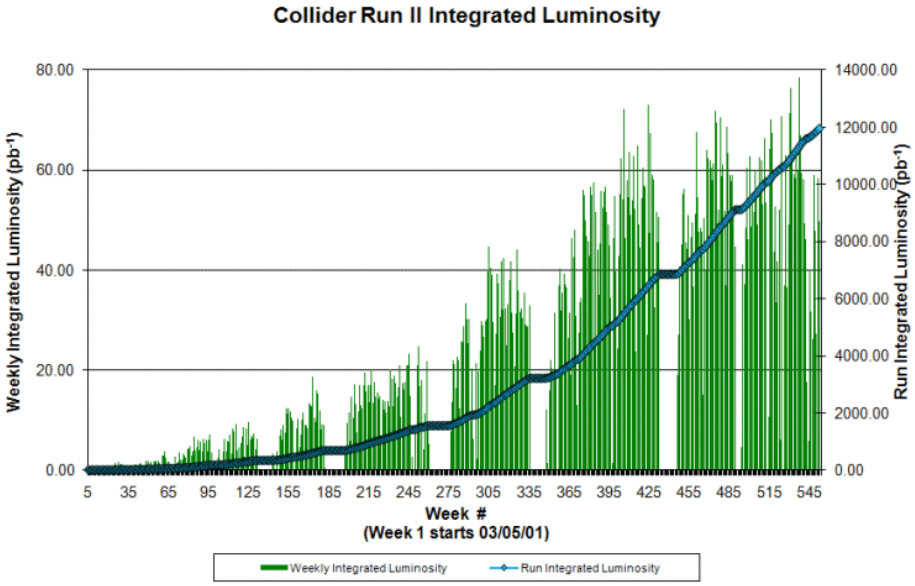




CDF



DØ



- $p\bar{p}$ collisions at 1.96 TeV (Run II, 2001-2011).
- Peak lumi $\approx 4 \cdot 10^{32}\mathrm{cm}^{-2}\mathrm{s}^{-1}$
- About $12\,\mathrm{fb}^{-1}$ delivered to experiments.
  Acquired $10\,\mathrm{fb}^{-1}$ / experiment
- Collaborations :
  - Currently 400 + 400 members
  - 60 (CDF) + 70 (DØ) Institutions

Matrix Element Method

- **Matrix Element (ME)**
  - Define *per-event* probability by Leading Order ME of signal ($t\bar{t}$) and Bkg events as a function of M_{top}, JES and the expected fraction of signal $f_{t\bar{t}}$:

$$P_{ev}\,(\vec{y},\ f_{t\bar{t}},\ M_{top},\ JES) = f_{t\bar{t}} \cdot P_{t\bar{t}}\,(\vec{y},\ M_{top},\ JES) + (1 - f_{t\bar{t}}) \cdot P_{bkg}\,(\vec{y},\ JES)$$

$$P_{t\bar{t}} \propto \frac{1}{N} \int \underbrace{f(z_1)\, f(z_2)\, dz_1\, dz_2}_{\text{p.d.f.}}\ \underbrace{\mathcal{W}(\vec{y},\ \vec{x},\ JES)}_{\text{Transfer function}}\ \underbrace{d\sigma_{t\bar{t}}(\vec{x},\ M_{top})}_{\substack{\text{differential} \\ \text{x-section}}}$$

  - P_{bkg} totally analogous, but $d\sigma_{bkg}(\vec{x})$.
  - P_{ev} gives the probability for the *observed* event kinematics, $\vec{y}$, to arise from a signal or a bkg event.
  - N : Normalization factor
  - $f(z)$: Parton density functions
  - $\mathcal{W}\,(\vec{y},\ \vec{x},\ JES)$: Connect observed jets to partons. Give the probability for the *measured* jet momenta $\vec{y}$ given corresponding parton momenta $\vec{x}$. Depend on the Jet Energy Scale.
  - $d\sigma(\vec{x})$: Include ME calculation and phase space. Depend on M_{top} for $t\bar{t}$ events.
- **Maximize sample likelihood** $\mathcal{L}\,(\vec{y},\ f_{t\bar{t}},\ M_{top},\ JES) = \prod_{events} P_{ev}$

Template Method

- **CDF, Lepton + Jets : χ^2 expression for m_t^{reco} (free parameters m_t^{reco}, $p_{T,i}^{fit}$ and U_j^{fit})**

$$\chi^2 = \frac{\left(m_{jj} - M_W\right)^2}{\Gamma_W^2} + \frac{\left(m_{l\nu} - M_W\right)^2}{\Gamma_W^2} + \frac{\left(m_{jjb} - m_t^{reco}\right)^2}{\Gamma_t^2} + \frac{\left(m_{l\nu b} - m_t^{reco}\right)^2}{\Gamma_t^2} + \sum_{i=l,jets} \frac{\left(p_{T,i}^{fit} - p_{T,i}^{meas}\right)^2}{\sigma_i^2} + \sum_{j=x,y} \frac{\left(U_j^{fit} - U_j^{meas}\right)^2}{\sigma_j^2}$$

- **CDF, All-Hadronic : χ^2 expression for m_t^{rec} (free parameters m_t^{rec} and $p_{T,i}^{fit}$)**

$$\chi^2 = \frac{\left(m_{jj}^{(1)} - M_W\right)^2}{\Gamma_W^2} + \frac{\left(m_{jj}^{(2)} - M_W\right)^2}{\Gamma_W^2} + \frac{\left(m_{jjb}^{(1)} - m_t^{rec}\right)^2}{\Gamma_t^2} + \frac{\left(m_{jjb}^{(2)} - m_t^{rec}\right)^2}{\Gamma_t^2} + \sum_{i=jets} \frac{\left(p_{T,i}^{fit} - p_{T,i}^{meas}\right)^2}{\sigma_i^2}$$

  - $m_{jj}, m_{l\nu}$: **Invariant masses of dijet and lepton-neutrino systems**
  - $m_{jjb}, m_{l\nu b}$: **Invariant masses of three-particle systems including b-jets**
  - $p_{T,i}^{meas}, \sigma_i$: **Measured transverse momenta of lepton, jets and uncertainties**
  - U_j^{meas}, σ_j : **components of unclustered energy and uncertainties.**
  - M_W, Γ_W, Γ_t : **Mass of W boson and widths of W and top quark**

M_{top} WORLD AVERAGE

- **Uncertainties**

	Input measurements and uncertainties in GeV											
	CDF				D0		ATLAS		CMS			World
Uncertainty	l+jets	di-l	all jet	E_T^{miss}	l+jets	di-l	l+jets	di-l	l+jets	di-l	all jet	Combination
m_{top}	172.85	170.28	172.47	173.93	174.94	174.00	172.31	173.09	173.49	172.50	173.49	173.34
Stat	0.52	1.95	1.43	1.26	0.83	2.36	0.23	0.64	0.27	0.43	0.69	0.27
iJES	0.49	n.a.	0.95	1.05	0.47	0.55	0.72	n.a.	0.33	n.a.	n.a.	0.24
stdJES	0.53	2.99	0.45	0.44	0.63	0.56	0.70	0.89	0.24	0.78	0.78	0.20
flavourJES	0.09	0.14	0.03	0.10	0.26	0.40	0.36	0.02	0.11	0.58	0.58	0.12
bJES	0.16	0.33	0.15	0.17	0.07	0.20	0.08	0.71	0.61	0.76	0.49	0.25
MC	0.56	0.36	0.49	0.48	0.63	0.50	0.35	0.64	0.15	0.06	0.28	0.38
Rad	0.06	0.22	0.10	0.28	0.26	0.30	0.45	0.37	0.30	0.58	0.33	0.21
CR	0.21	0.51	0.32	0.28	0.28	0.55	0.32	0.29	0.54	0.13	0.15	0.31
PDF	0.08	0.31	0.19	0.16	0.21	0.30	0.17	0.12	0.07	0.09	0.06	0.09
DetMod	< 0.01	<0.01	<0.01	<0.01	0.36	0.50	0.23	0.22	0.24	0.18	0.28	0.10
b-tag	0.03	n.e.	0.10	n.e.	0.10	<0.01	0.81	0.46	0.12	0.09	0.06	0.11
LepPt	0.03	0.27	n.a.	n.a.	0.18	0.35	0.04	0.12	0.02	0.14	n.a.	0.02
BGMC	0.12	0.24	n.a.	n.a.	0.18	n.a.	n.a.	0.14	0.13	0.05	n.a.	0.10
BGData	0.16	0.14	0.56	0.15	0.21	0.20	0.10	n.a.	n.a.	n.a.	0.13	0.07
Meth	0.05	0.12	0.38	0.21	0.16	0.51	0.13	0.07	0.06	0.40	0.13	0.05
MHI	0.07	0.23	0.08	0.18	0.05	<0.01	0.03	0.01	0.07	0.11	0.06	0.04
Total Syst	0.99	3.13	1.41	1.36	1.25	1.49	1.53	1.50	1.03	1.46	1.23	0.71
Total	1.12	3.69	2.01	1.85	1.50	2.79	1.55	1.63	1.06	1.52	1.41	0.76