Studio di fattibilità di una misura della massa del quark top in produzione di coppie $t\bar{t}$ nel canale dileptonico ad LHC e a futuri collisionatori adronici

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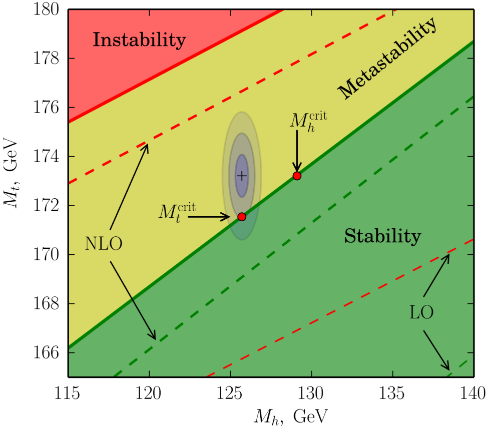
Importance of a precise top mass determination

The Top Mass is a sensible parameter of the SM:



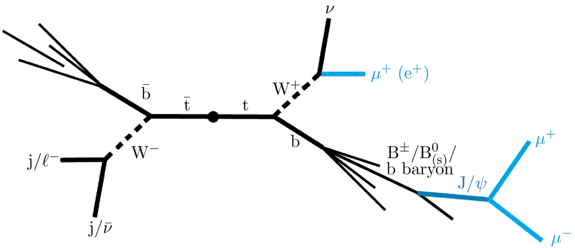
See *e.g.* *A.V. Bednyakov,*
"An advanced precision analysis of the SM vacuum stability",C16-04-12.1
and references therein

- For a review on methods of top mass measurements: *A. Juste et al.,,Eur. Phys. J.,C74,2014,3119*
- The determination of the top quark mass m_t at hadron colliders is as much dependent on theoretical assumptions as it is on measurements:

m_t (GeV/c^2)	Source	$\int \mathcal{L}dt$	Ref.	Channel
$172.99 \pm 0.48 \pm 0.78$	ATLAS	4.6	[123]	ℓ+jets+$\ell\ell$
$172.04 \pm 0.19 \pm 0.75$	CMS	19.7	[124]	ℓ+jets
$172.47 \pm 0.17 \pm 1.40$	CMS	19.7	[131]	$\ell\ell$
$172.32 \pm 0.25 \pm 0.59$	CMS	19.7	[134]	All jets
$174.34 \pm 0.37 \pm 0.52$	CDF,DØ (I+II)	$\leq$9.7	[145]	publ. or prelim
$173.34 \pm 0.27 \pm 0.71$	Tevatron+LHC	$\leq$8.7+$\leq$4.9	[3]	publ. or prelim

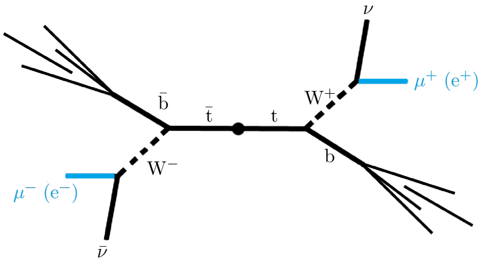
Example: J/Ψ method

- Several methods circumvent the problem studying leptonic observables, in different ways (see also *De Santis* in this conference): which leptons?
- Consider, *e.g.*, J/Ψ method:
  - Clean final state, only leptonic observables
  - ... but: depends on modelling of hadronisation process



Measuring top mass with leptonic variables only

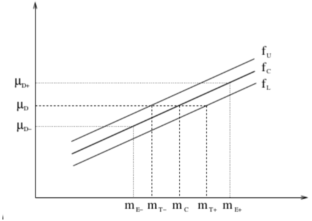
- See *Frixione, S. & Mitov, A. J. High Energ. Phys. (2014)*, **reference paper of this talk**
- The idea is to study the top mass dependence on *intrinsically* leptonic observables, dilepton channel:



Measuring top mass with leptonic variables only

- Theoretical handle: Mellin's moments of *several* leptonic observables, combined.

$$\mu^{O}_{(i)} = \frac{1}{\sigma} \int d\sigma \, O^{i}$$



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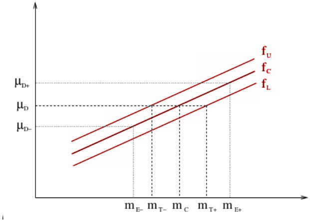
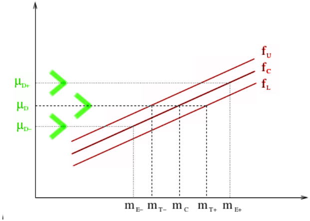


- Theoretical handle: Mellin's moments of *several* leptonic observables, combined.

$$\mu^{O}_{(i)} = \frac{1}{\sigma}\int d\sigma\, O^{i}$$

- Compute moments dependence on m_t
- Measure moments

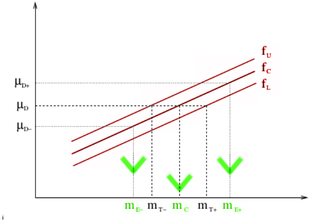


Measuring top mass with leptonic variables only

- Theoretical handle: Mellin's moments of *several* leptonic observables, combined.

$$\mu_{(i)}^{O} = \frac{1}{\sigma} \int d\sigma O^{i}$$

- Compute moments dependence on m_t
- Measure moments
- Determine corresponding m_t

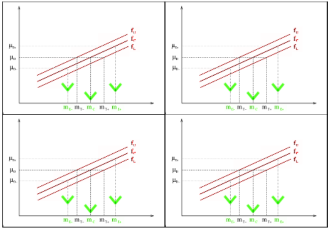


Measuring top mass with leptonic variables only

- Theoretical handle: Mellin's moments of *several* leptonic observables, combined.

$$\mu^{O}_{(i)} = \frac{1}{\sigma} \int d\sigma \, O^i$$

- Compute moments dependence on m_t
- Measure moments
- Determine corresponding m_t
- Repeat for different observables, and combine



Feasibility study

Two directions:

- Derivation of systematic uncertainties associated to the determination of m_t
    - Detector related
    - PDF set choice
- Extension of the Moments computation at Future hadronic colliders (not in this talk):
    - MadGraph_aMC@NLO + Pythia8 + Delphes within the FCCSW+Heppy framework
        - The same study can be recasted as a measurement of PDF at FCC energies
        - Same method to measure different observables at FCC-hh
        - Top partner mass ?

Event definition

Process generation

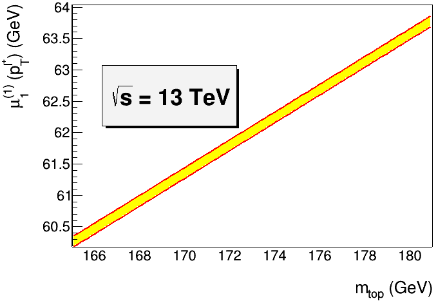
- $t\bar{t} \rightarrow b\bar{b}\mu\nu_{\mu}e\nu_{e}$, 310000 events
- Since we are interested in uncertainties estimations, we produced samples with LO accuracy

First raw selection cuts (moments depend on them):

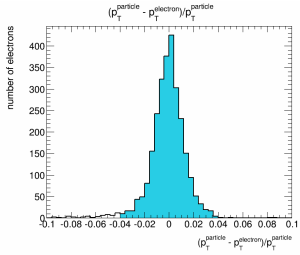
- Leptons $p_T > 20 GeV$
- Leptons $|\eta| < 2.4$ Computed variables, up to 4th moment:
  - $p_T^{l^+}$, $p_T(l^+l^-)$, $m_{inv}(l^+l^-)$, $p_T^{l^+} + p_T^{l^-}$,$E_{l^+} + E_{l^-}$
  - New respect to reference paper: $p_T(l^- - l^-)$

Hardest lepton p_T, μ_1, detector related effects:

Parton/reco comparison



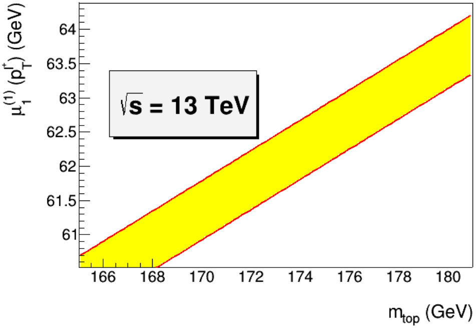
Delphes JHEP02(2014)057



Related estimated uncertainty: 0.5 GeV (before combination)

Representative results

Hardest lepton p_T, μ_1, pdf dependence:



- Related estimated uncertainty: 1.9 GeV at LO (before combination)
- Preliminary, need checks (NLO, statistics)

Combination

- Results from different observables have to be combined, taking into account correlations (24×24 matrix)
- As an example, pdf set choice systematic error is computed to be

$$1.5 \text{ GeV, LO}$$

  and is dominated by more sensitive variables, e.g. $p_T^{l^+}$:
- Preliminary results, somehow still affected by numerical statistical uncertainty

Conclusions and outlook

Idea of determining m_t using leptonic observables distributions via Mellin's moments

- We are studying systematics associated to this method:
  - First result on pdf set choice: is at the $1.5 GeV$, needs checks
- Computed moments at FCChh

Future developments:

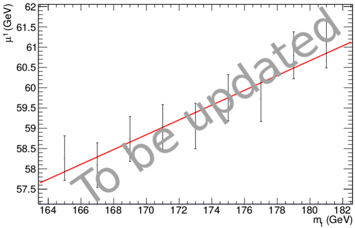
- Background effect estimation, unfolding
- Extend study of systematic uncertainties to Initial/Final State radiation and other relevant systematics

BackUp

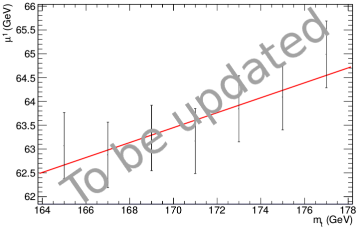
Representative results

Hardest lepton p_T, μ_1, LHC vs FCChh:

LHC



FCChh



Correlation matrix, first moments only

	$\mu_1^{(1)}$	$\mu_2^{(1)}$	$\mu_3^{(1)}$	$\mu_4^{(1)}$	$\mu_5^{(1)}$	$\mu_6^{(1)}$
$\mu_1^{(1)}$	1	0.396	0.598	0.538	0.776	0.719
$\mu_2^{(1)}$	0.396	1	0.114	0.334	0.504	0.218
$\mu_3^{(1)}$	0.598	0.114	1	0.663	0.774	0.823
$\mu_4^{(1)}$	0.538	0.334	0.663	1	0.694	0.648
$\mu_5^{(1)}$	0.776	0.504	0.774	0.694	1	0.926
$\mu_6^{(1)}$	0.719	0.218	0.823	0.648	0.926	1