Top mass extraction from leptonic distributions in dilepton final states

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Why bring this problem?

- ✓ Top mass is now known with 1GeV accuracy.
  Question: could there be a hidden systematics which is as large as, say, 1 GeV?

- ✓ The rationale: the top mass is not observable and thus cannot me “measured”

- ✓ It can be inferred from data based on some theory input. So if the theory input is incomplete the extracted mass is imperfect (even for a perfect measurement)

Where does M_{TOP} matter?

- ✓1 GeV uncertainty is plenty in collider physics (W mass is bottleneck in EW precision fits)

- ✓ Fate of the Universe is different story: 1 GeV change in M_{TOP} makes all the difference

- ✓ Interesting QCD question: how do we determine the top mass?

How to determine M_{TOP}?

- ✓ Many approaches exist

- ✓ The most natural way is:
  - ✓ take an observable O(M)
  - ✓ compute it
  - ✓ measure it
  - ✓ extract M

See 2013 review by:
Aurelio Juste, Sonny Mantry, Alexander Mitov, Alexander Penin, Peter Skands, Erich Varnes, Marcel Vos, Stephen Wimpenny

Which observable to use?

- ✓ Idea: use dilepton events. Why?
  - ➢ Most past top determinations rely heavily on MC's.
  - ➢ Dilepton events allow us to be less-dependent on modeling of hadronic activity.
  - ➢ The observable is:
    - inclusive
    - well-defined to all orders, etc

- ✓ Definition:
  - ✓ events containing 2 leptons and 2 b-quarks
  - ✓ do not care about the kinematics of b's; only require them inside of detector
  - ✓ study kinematical distributions constructed ONLY from the 2 leptons

- ✓ Implications:
  - We are fully inclusive in all radiation beyond the 2 b's
  - We are rather inclusive in the two b's: we integrate them over the detector.

Calculational tool of choice: aMC@NLO

✓ The logic is: the observable is inclusive.

✓ Implication: could be computed at fixed order.

✓ We want to verify this: showered calculation needed.

aMC@NLO offers it all!

What are the drawbacks of such an approach (i.e. m_{top} from dilepton distributions)?

- Only one known: could the sensitivity of the distributions to M_{TOP} be small?

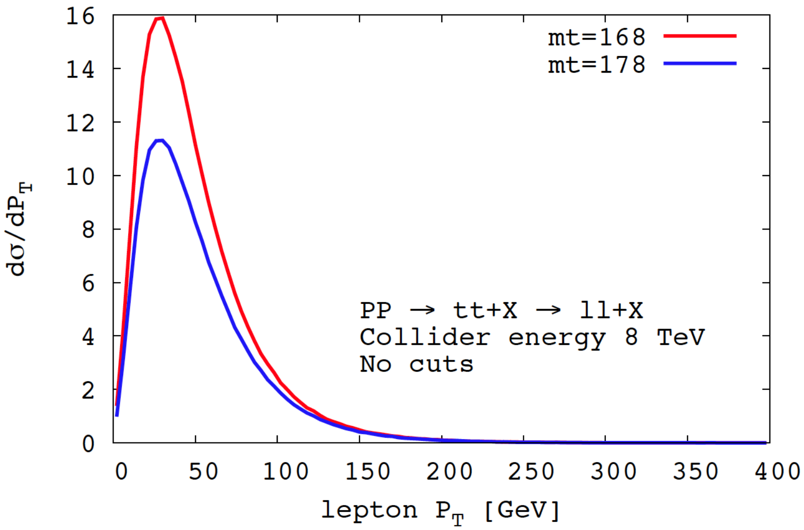
I mentioned dilepton distributions. Here is what we consider (must be dimension-full)

1) Lepton p_T
2) Lepton pair p_T
3) Lepton pair invariant mass
4) Sum of the energies of the two leptons (considered '10 by Biswas, Melnikov, Schulze)
5) $P_{T1} + P_{T2}$ (scalar sum)

Plan for work:

✓ Compute:
- NLO + shower with/out spin correlations (MadSpin)
- full off-shell NLO fixed order (done; will not show)
- LO (done; will not show)
- 3 different functional forms for mu_R , mu_F
- MSTW pdf sets (at NLO or LO and for pdf variation)
- scale variation: independent mu_R and mu_F restricted variation
- compute for: no cuts, cuts (standard CMS), cuts + isolation

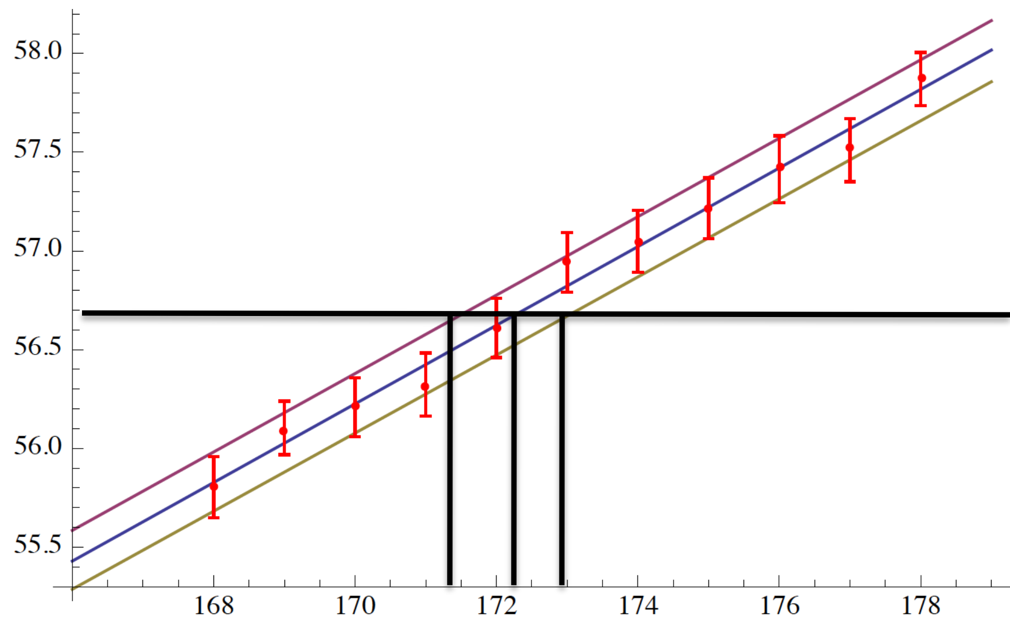
✓ Extract the 1-st moment of the distributions (as subject to cuts etc; per-event)
✓ Compute PDF/scale uncertainty for the moment
✓ From 11 masses in (168,178) find the fits for (central, +err, -err)



Normalize each Distribution.

➔

Then compute 1^{st} moment



✓ Measure the moment (small error, very clean); from the plot infer M_{TOP} and its error.

First results: (all is very preliminary)

- 8 TeV is not worse (maybe even better) than 14 TeV

- Vary: choice of scale

  - fixed scale: mu = M_{TOP}
  - dynamic scale: mu = $H_T/2$, $(M_{T,t} + M_{T,T})/2$

- Vary: MadSpin: included or not

<u>How to assess the results and interpret them</u>?

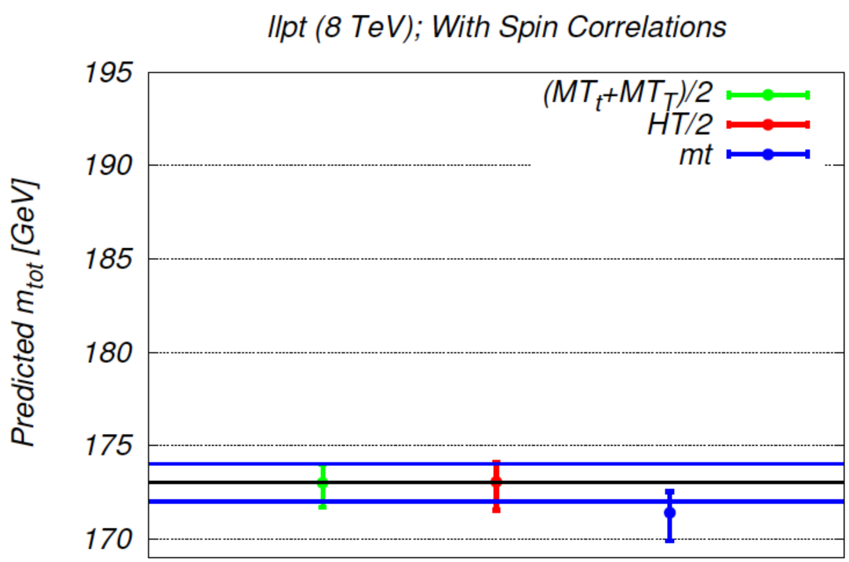
- Assume a value for the moment (eventually, the measured value, which is unique)
  Take a value which returns M_{TOP} = 173 (for the "best" prediction)

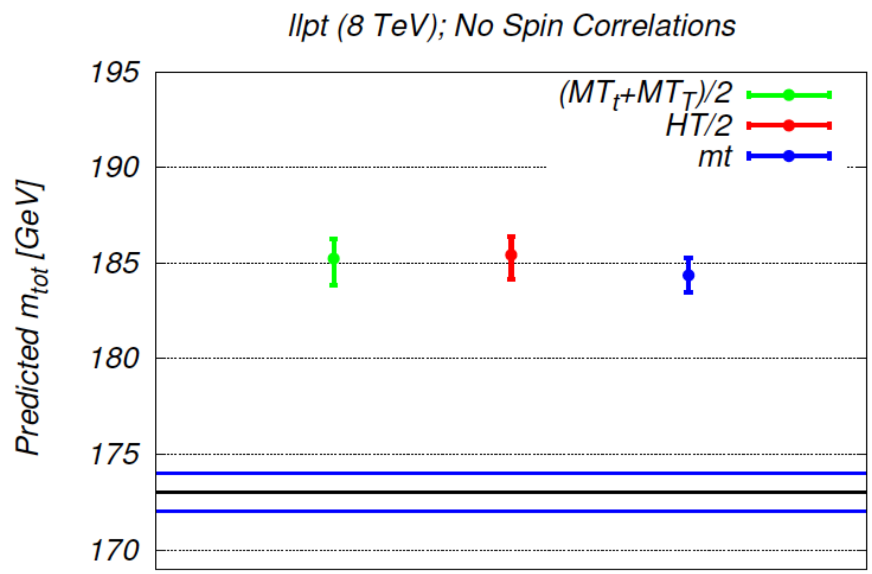
- For each one of the 5 distributions invert mu to derive M_{TOP}

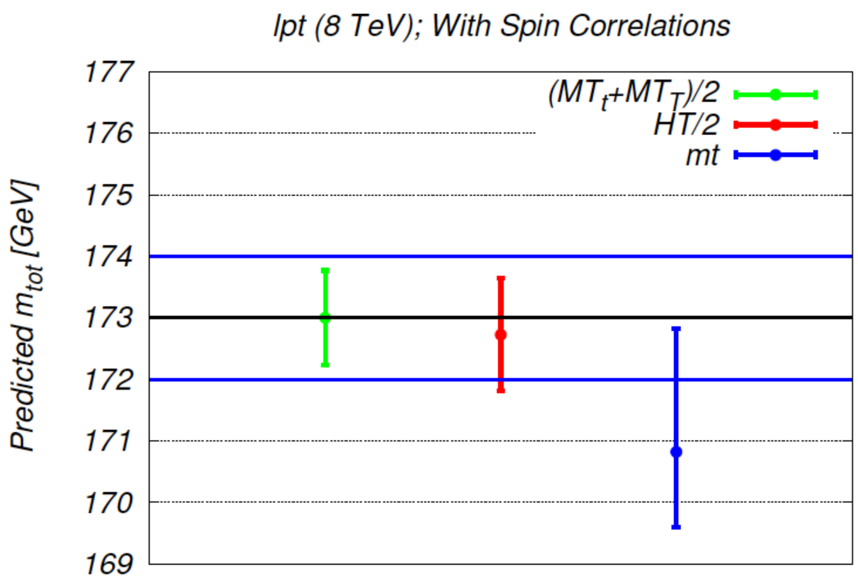
- Compare the inferred masses, together with the uncertainties.

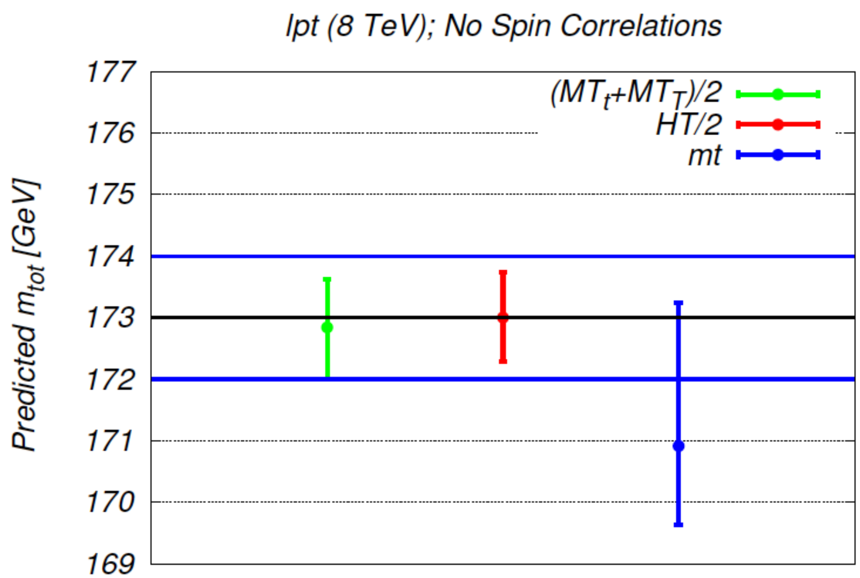
- Interpret the results: do they agree? Or not? Why? etc.

Extracted top mass for some **assumed** measurement with m_{top}=173 GeV: (preliminary)









Concluding comments (preliminary)

✓Spin correlations:

- ✓ hugely important for pair P_T and pair invariant mass
- ✓ unimportant for single lepton P_T, sum of P_T and sum of energies

✓ We have considered 5 observables. Are there more? Should we consider likelihood?

- ✓ A concern: splitting observables might be good for seeing effects (previous slide).

✓ Choice of scale makes some difference (dynamic vs. fixed) but all is within uncertainties

✓ Sub-1 GeV m_{top} extraction possible (TH error only):

Single lepton P_T : $\Delta m_{top} = \pm 0.8$ GeV
Sum of lepton P_T's : $\Delta m_{top} = \pm 0.8$ GeV
Sum of lepton energies: $\Delta m_{top} = \pm 2.0$ GeV

← Insensitive to spin correlations

Lepton pair P_T : $\Delta m_{top} = \pm 1.1$ GeV
Pair inv. mass : $\Delta m_{top} = \pm 1.6$ GeV

← Very sensitive to spin correlations