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“What -- *in my personal opinion* -- should be the highest level conclusions of the Energy Frontier report?"

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The Ohio State University
Seattle Snowmass Meeting of the Energy Frontier
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EF offers unique scientific opportunities for many years to come

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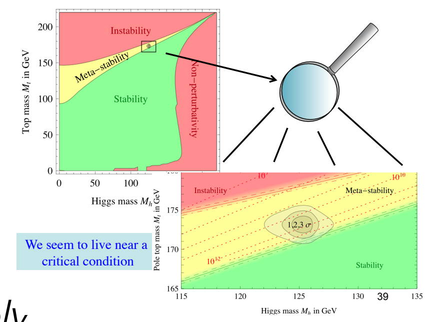
- There are very good reasons to expect discovery(ies) with EF research
- LHC will go to 13/14 TeV and push energy frontier higher in a region we all agree is (still) critical to explore
    - *All old reasons (e.g. hierarchy problem) more or less remain valid*
        - **Despite increasing efforts to close them, loop-holes remain in current searches**
            - BR, compressed spectra, stealth/RPV, long-lived pls, non-natural scenarios
    - *Some new ones now that we have Higgs (e.g. vacuum (meta)stability)*
    - *DM can be discovered directly via monojets+MET, or confirmed by LHC (and possibly identified) if first observed in CF*
    - *Unexplored energies, should not discount unexpected surprises*
    - *Need HL-LHC to carry out full search program*
        - **Broadband energy of hadron colliders provides needed flexibility**
- If on the other hand discovery comes already in Run 2, can study with HL-LHC (and possibly some phase of ILC)
- If no discovery comes by end of HL-LHC, precision Higgs physics can identify next directions in HEP
    - *HL-LHC will probe BSM effects via couplings, HH, VV*
    - *ILC (or possibly other machines) can take over where HL-LHC leaves off*
- Significant deviations from SM will motivate (appropriate) machine(s) to identify source of NP



EF is about discovery

Maximize these Opportunities

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- To carry out the discovery (and precision) program HL-LHC needs significant upgrades as has been noted
  - *Should not assume these will be be fully funded*
    - **And short-changing will limit physics opportunities, maybe miss discoveries**
  - *Should not discount game changers, which could have a big impact on physics*
    - **New detectors can significantly alter projections (some require R&D, should enable)**
      - 1 MHz L1 bandwidth changes trigger landscape, even more so if tracks are available
      - Forward pixel disks could dramatically change VBF tagging capability at highest PU, ditto for precision timing in calorimeters
    - **Experience with data leads to algorithmic performance exceeding naive expectations**
      - Many examples in CMS (e.g. particle flow, PU mitigation, VBF, b-tagging in HI collisions, …)
    - **Physics**
      - Discoveries may make different demands on the detectors than we can anticipate now; a well upgraded detector will be able to adjust to these needs
  - *Opportunity for US to continue successful collaboration in Europe*
    - **Expand impact beyond already significant roles on LHC**
    - **Facilitate more global involvement (LBNE, ILC) that may be reciprocated**
      - This is a way to avoid the zero-sum trap

Report should address these (Abid)

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Energy Frontier Issues

- **Discussions with CERN about follow-on to LHC Agreement proceeding**
  - Necessary precursor to planning for "Phase-II" upgrades; US scope for "Phase-II" TBD.
- **Energy Frontier science plan will require high-energy, high-luminosity LHC running**
  - What is the real physics of the TeV scale?
    - this will likely take a few years to sort itself out
  - US "Snowmass/P5" process is an important element, along with European and Japanese HEP strategies
- **Significant collaborations with other regions on future colliders will require a high-level approach between governments**
  - Modest ground-level R&D efforts can continue as funding allows
  - We support an international process to discuss future HEP facilities that respects the interests of major national and regional partners as well as realistic schedule and fiscal constraints
  - Once Snowmass/P5 studies and the community input are complete, we will be in a better position to evaluate future US priorities for the HEP program in detail
  - We encourage active engagement by all interested parties

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IMO a conclusion should be that the community fully supports these (which are related)

I also think we should express support for these statements

What (i think) we should probably avoid concluding *in the report*

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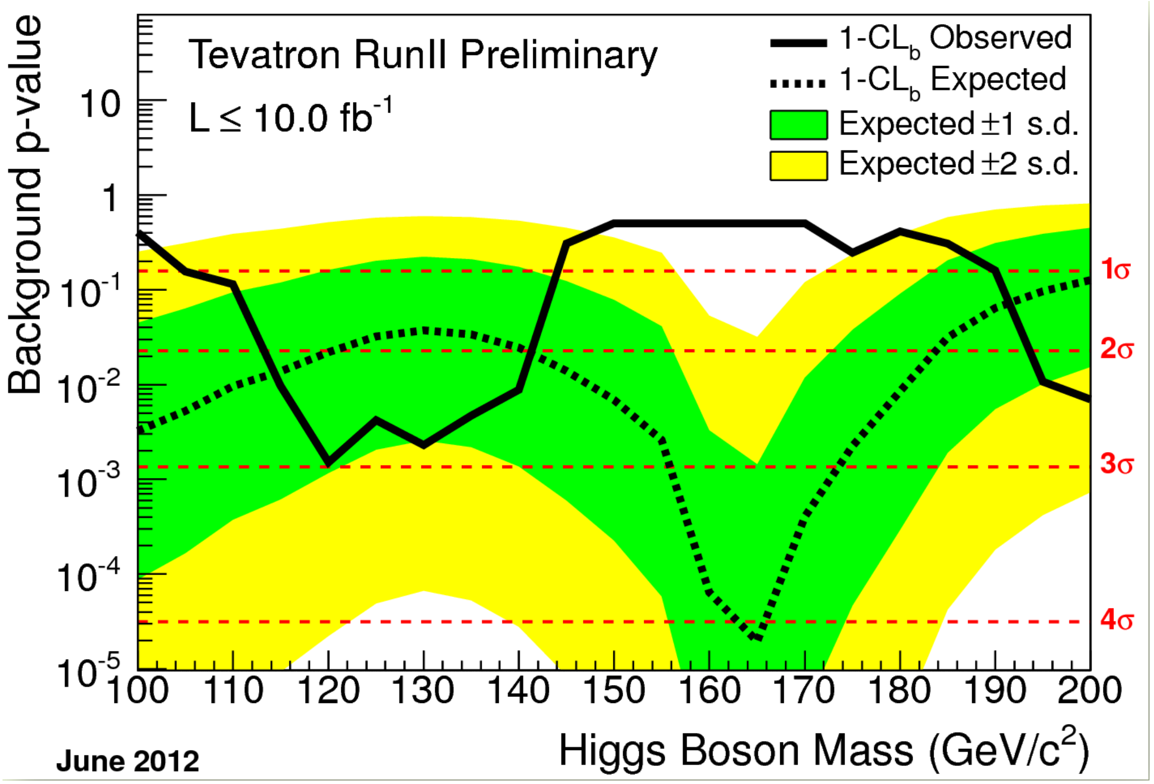
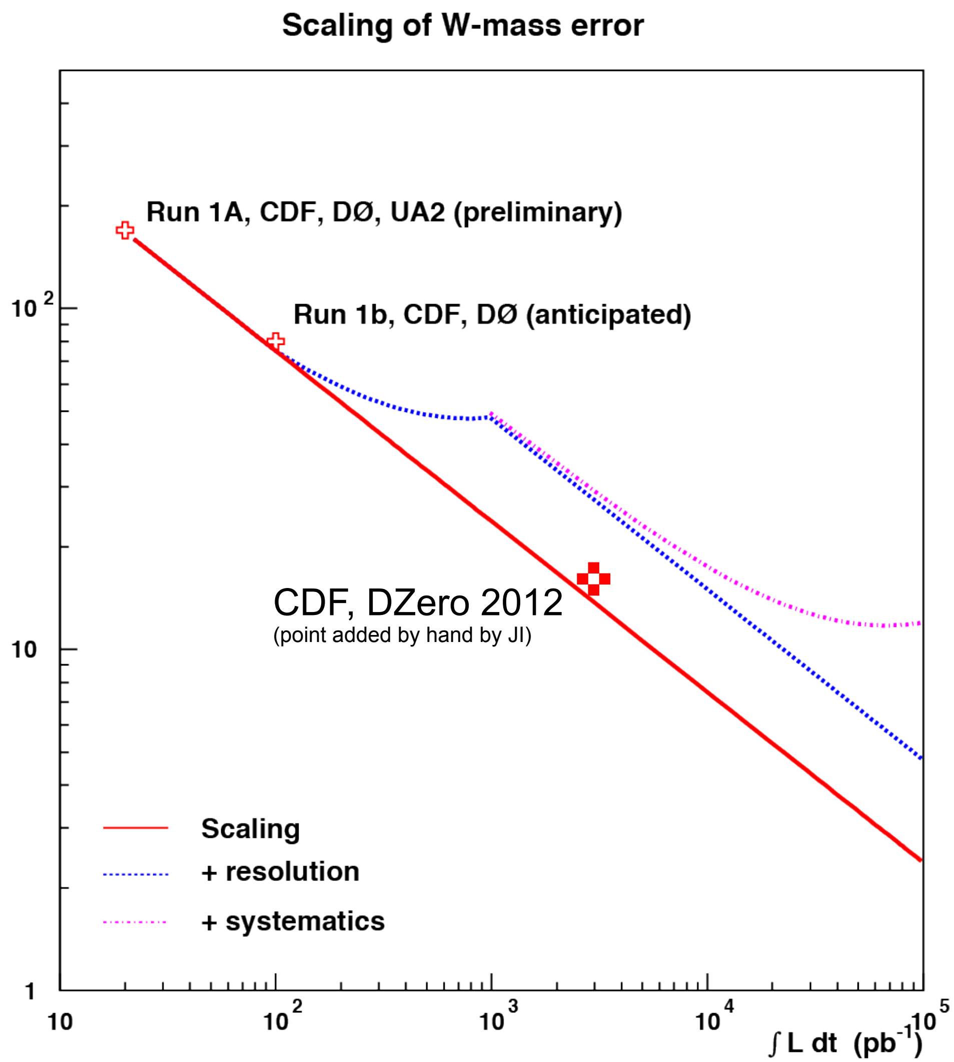
- One facility offers better/worse opportunity for discovery than another *because* Snowmass studies indicate relative greater/lesser precision on Higgs couplings (or other SM parameters)
  - *Firstly, we should not assume it is a zero-sum game at this point*
  - *Secondly, we need error bars on the error bars (or ranges)*
    - **Not just to represent uncertainties on the estimates, but also to show range of impact of action(inaction) on opportunities**
    - **Allow in the estimates for (experimental & theoretical) improvements that have historically been achieved**
  - *Thirdly, the conclusion does not follow from the data. Arbitrary precision is not the goal - discovery is, and for discovery one needs to ask what precision is required to distinguish a NP model from the SM*
    - **More than this is unnecessary, less is insufficient**
    - **Without a well-defined model, can't answer this question**
      - Scans over model space are a very interesting attempt to address this, but come with their own issues
  - *Finally, in prioritization phase, what we say, can and will be used against us (us being EF)*
    - **Internally, debate is healthy ("kick the tires") but externally a lack of consensus on #s hurts**

Additional Material

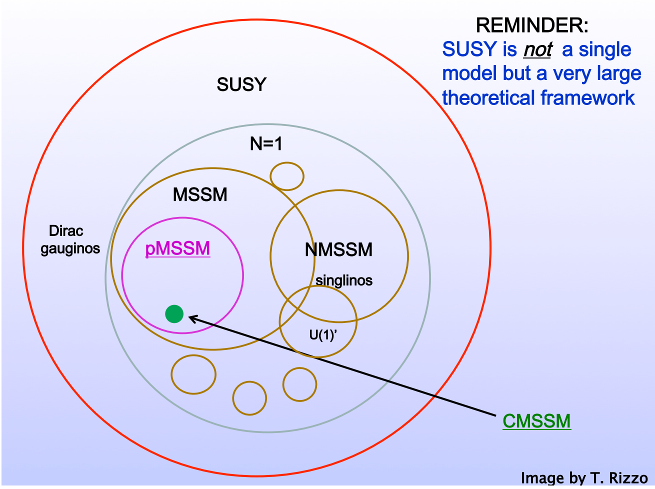
We have found promising sensitivity for the discovery of an intermediate-mass Higgs boson at the Tevatron via the process $q\bar{q} \to WH$, with $H \to b\bar{b}$. We tentatively conclude that a Higgs mass of 80 GeV can be reached with about 5 fb^{-1}, a mass of 100 GeV with about 10 fb^{-1}, and a mass of 120 GeV with about 25 fb^{-1}. These results are very encouraging, and suggest that the Tevatron could play a significant role in the quest for an intermediate-mass Higgs boson.

TeV2000 (1996)





TeV2000
(1996)



J. Hewett (Sunday's talk)

300 fb^{-1}: 92.1% of models excluded

3 ab^{-1}: 97.5% of models excluded