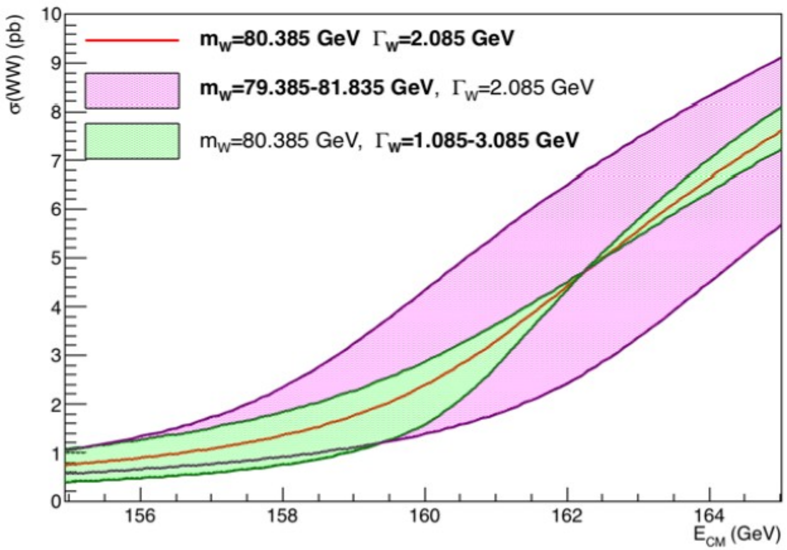
Measurement of m_W at threshold (thoughts)

- A few remarks about the post-LHC context
  - Last measurements and combination:
    - CDF : δm_W ~ 19 MeV; D0 : δm_W ~ 23 MeV (Tevatron average : 15 MeV)
    - ATLAS : δm_W ~ 19 MeV
    - New average : dm_W ~ 11-13 MeV, depending on uncertainty correlations
  - Foreseen sensitivity : 5-10 MeV, assuming measurements at roots = 5, 7, 8 and 13 TeV.
  - Further improvement might be possible with the upgraded LHC detectors, in the HLLHC era (using dedicated, low pile-up runs)
- To be interesting, the goal at CEPC should be well below 5 MeV

Recent study : arXiv:1703.01626

- Studied the statistical precision on m_W from 1-point and 2-point cross section measurements



1-point example :
At 162.3 GeV, the cross section is maximally sensitive to m_W, and insensitive to the width

Statistical uncertainty assuming 15 ab^{-1} (one FCC-ee year): $\delta m_W \sim 0.25$ MeV

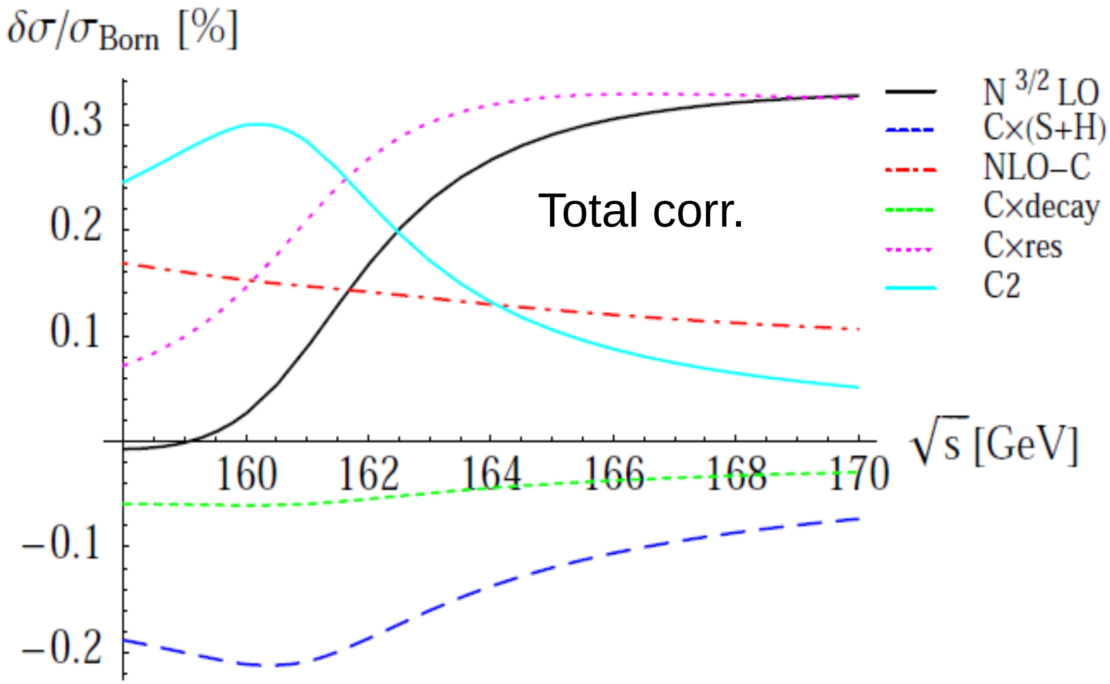
Requirements on systematic uncertaintes:

Beam energy	dE/E	$< 3\ 10^{-6}$	OK?
Luminosity	dL/L	$< 10^{-4}$	OK?
Cross section prediction	$d\sigma_{th}/\sigma_{th}$	$< 10^{-4}$	Limiting

With two-point measurement, achieve $\delta m_W \sim 0.4$ MeV, $\delta\Gamma_W \sim 1$ MeV

Present theoretical uncertainties

- Contributions to the NNLO corrections (arXiv:0807.0102):



The authors estimate that the uncertainties from missing NNLO corrections amount to δm_W~3 MeV. δm_W~1 MeV is deemed achievable in the mid-term.

Note : the different terms have rather different energy dependence – the theoretical uncertainty is not reduced by measuring at different points

Situation with 3.2 ab^{-1}

- Statistical uncertainty: $\delta m_W \sim 0.6$ MeV
- Requirements on systematic uncertaintes:
  - Beam energy dE/E $< 10^{-5}$ OK?
  - Luminosity dL/L $< 2\ 10^{-4}$ OK?
  - Cross section prediction $d\sigma_{th}/\sigma_{th}$ $< 2\ 10^{-4}$ Still limiting

- Although the W width is not too important for BSM, measuring the cross section at at least two points allows to measure both m_W and Γ_W, making the mass measurement less model-dependent

- Brief summary : at present, 3.2 ab^{-1} is sufficient to make the statistical uncertainty sub-dominant, for a model-independent measurement at the ~2-3 MeV level.

  Further requirements are that

  - Complete NNLO corrections become available for ee → 4f (→ $dm_W \sim 1$ MeV)
  - The luminosity can be measured at the 0.02% level
  - The beam energy can be measured with a precision of 10^{-5}

Further studies

- Implement realistic running scenarios (ie cross section measurements at 1 / 2 / 5 points in energy, with a total luminosity budget of 3.2 ab^{-1}), detector acceptance, luminosity uncertainties etc, to produce a complete uncertainty table.
- I would be happy to collaborate on these issues, please let me know.

References (for my own record...)

- Beneke et al, arXiv:0707.0773v2, arXiv:0807.0102v1
- Snowmass 2013, arXiv:1310.6708v1
- Jadach et al, arXiv:hep-ph/0103163v3
- Dittmaier et al, arXiv:hep-ph/0505042v3
- FCC study, arXiv:1703.01626v1