Muon Collider analyses overview

Executive summary

Some brainstorm on possible analyses for the Muon Collider studies that could be performed in Torino

Constraints:

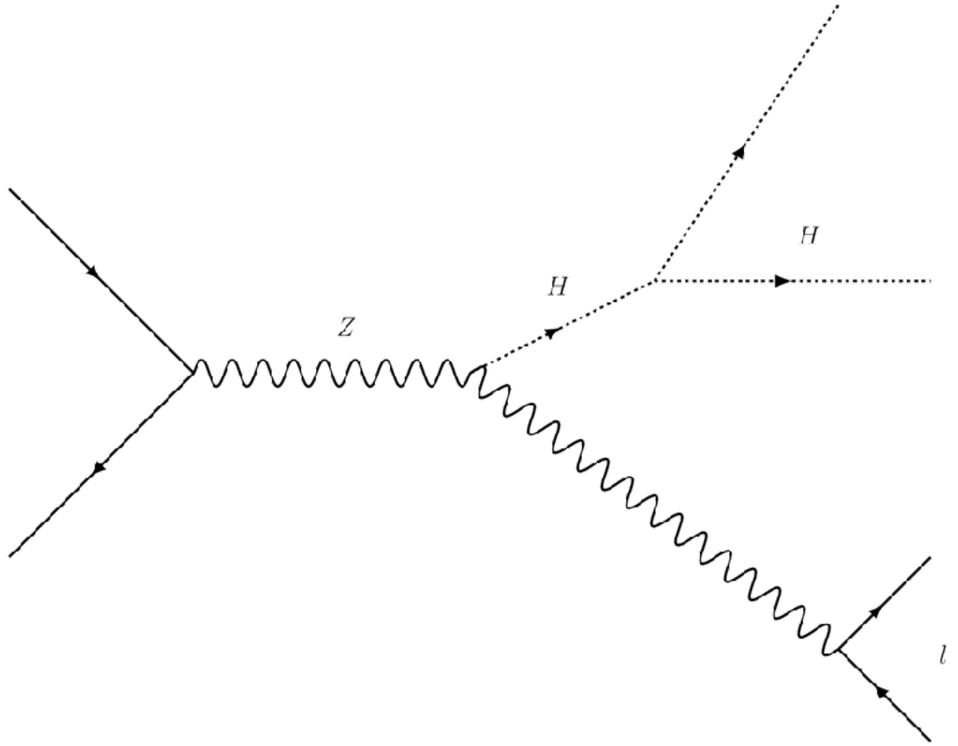
- Higgs analyses
- Expertise matching Torino activities
- Relatively simple final states, no huge systematics
- Relevant for future colliders (i.e. at first glance at least competitive with other future collider or impractical at other future colliders)

Ideas

- Double Higgs production in final states other than bbbb
- Double Higgsstrahlung (c2V anomalous coupling)
- Higgs width from off-shell production
- Higgs mass from Z recoil or from Hgg mass peak shift (least favourite)

1. HH production

- "Classic" HH analysis
- If there are few bkg jets, the advantage is clearly in the bbbb final state because of the larger BR
- We can explore other topologies that proved effective at LHC like bbtt, or focus on bbZZ which is our expertise
- But bbZZ has very low BR, if the final state is clean most of its advantages are lost…



2. Double Higgsstrahlung

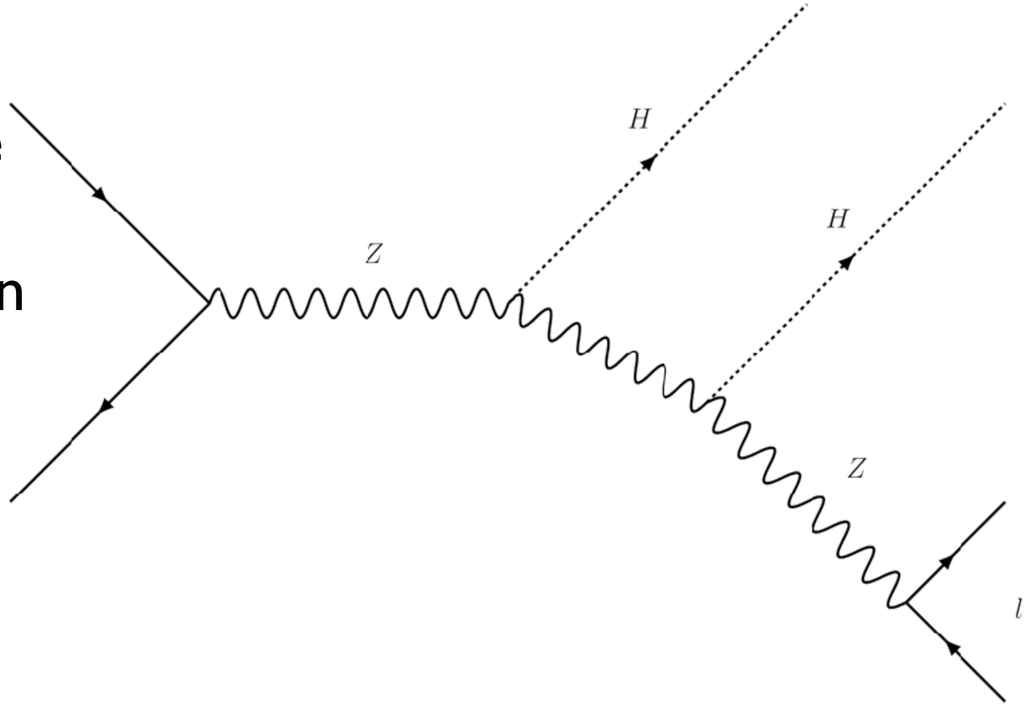
- Instead of having a H->HH decay, we can focus on the production of a second Higgs in the s-channel
  This is am irreducible(?) component of HH production

- H->HH has a ~1/1000 BR

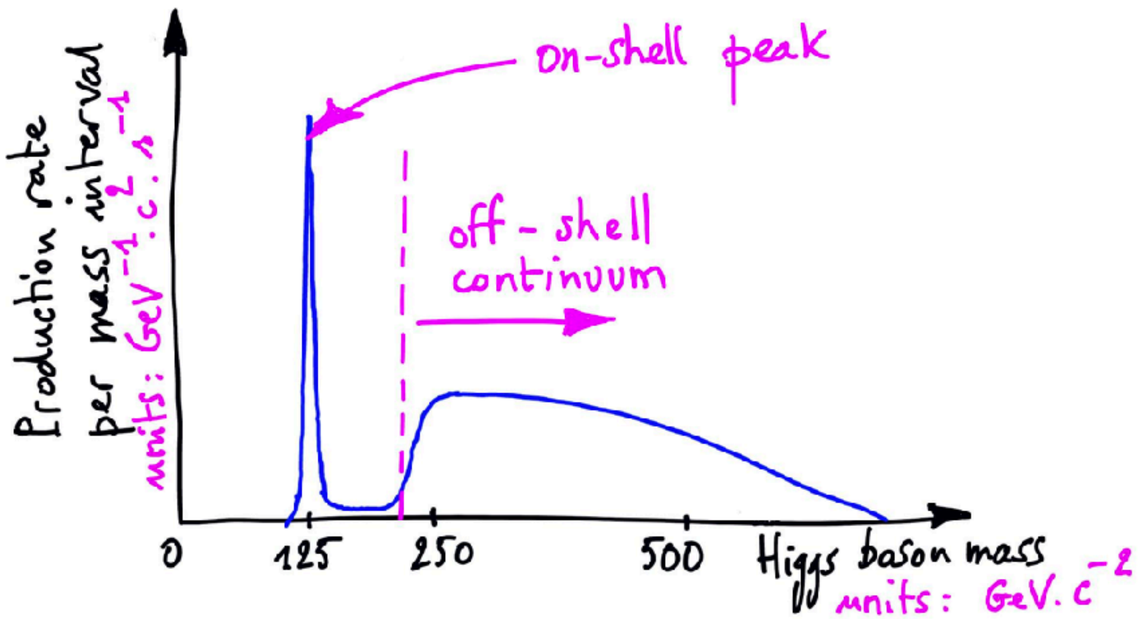
- 2H production could be more or less same order of magnitude (I didn't do the math yet)

- At the very least, it should be included in HH analyses.

- Possibly, it could provide the best measure of c2v, an anomalous coupling with important EFT effects, which is now only targeted in VBFHH



3. Width from offshell



First look (high likelihood of mistakes):

- sB = 7x10^{-6}pb
- sS = 3x10^{-14}pb
- sSBI = 2x10^{-7}pb

My personal favourite. CMS recently published this analysis on NatPhys. Torino were the first in the world doing it in 2013.

Off-shell H production in the ZZ channel is significant (~10%)

Width proportional to the ration of on-shell to off-shell production. Most precise way of measuring H width at LHC

The interference between signal and background reduces the overall x-section

Underlying assumption: no massive BSM particle <~1TeV (same as for Z-recoil)

In principle, if the Z emitting the H is energetic enough, it should be even better at the muon collider than LHC

4. Higgs mass

Fcc-ee is going to measure the Higgs mass with amazing precision (<10MeV!)

- Difficult to improve on this at the muon collider

We can nevertheless try some strategies that have been used for FCC or other studies

- Z-recoil: measure the recoil of the Z/H (like FCC-ee plans to do). Since this is a kinematically close process, the invariant mass of the H is the only unknown quantity. $m_H^2 = s + m_Z^2 - 2\sqrt{s}(E_+ + E_-)$
- Hgg peak shift due to the interference with the background.

Design problem: extremely precise measurements, we will need very good simulations to assess the real potential of the analysis.

- Is it worth it?